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The Single-Phase Motor for Electric Railways.

ALTHOUGH electricity has been very largely adopted in traction during recent years, progress in this direction has been hindered in no inconsiderable measure by the heavy cost of the machinery and distribution systems required for the utilisation of direct current on the one hand, and by the limitations of the polyphase induction-motor on the other. Tramway and light railway companies have called in the aid of electricity all over the country, but very little has been done towards the electrification of steam railways, and main lines have not yet been touched. The great railway companies are still in an attitude of expectancy; and, considering the enormous issues involved in any extensive change from existing methods of traction, their inaction is not unreasonable. Notwithstanding the activity displayed on the Continent in the adaptation of the three-phase alternating-current motor to railway-service, the direct-current motor is practically universal in this country. It is true that traction schemes are usually based on the generation of alternating current, but this has to be transformed and converted at sub-stations, requiring costly plant and constant attendance, and the transmission of low voltage current therefrom necessitates the employment of heavy and expensive conductors. The development of a motor equipment permitting the supply of alternating current to the trolley at high voltage, would result in very important savings, and should do much to encourage the adoption of electric traction on the railway system of Great Britain.

For several years engineers have been engaged in the endeavour to perfect a type of alternating-current equipment suitable for general traction work; and, latterly, attention has been chiefly directed to the possibilities of the single-phase motor. The development of the single-phase commutator motor, and its general suitability for traction purposes, have aroused much interest in railway circles. Until quite recently, however, there has been very little opportunity of obtaining useful information on the subject, as the only practical exemplification of the system was to be found in an experimental line in Germany. Consequently, the adoption of single-phase motors on the Ballston extension of the Schenectady Railway Company is of considerable importance. This installation is the first of its kind in the United States, and it is worthy of note that the motors are equally suitable for alternating or direct current. The extension is 15½ miles in length, including nearly 4 miles in Schenectady, where direct

current is supplied at 600 volts, and about 11½ miles of track having a supply of alternating current at 2,000 volts. A great recommendation of the compensated motor is that existing direct-current supplies can be utilised within urban limits, while the advantages of high-voltage distribution can be secured in suburban and country districts. This adaptability of the new equipment will undoubtedly facilitate the extension of tramway and light railway systems, quite apart from its influence on the electrification of steam railways.

The Ballston extension of the Schenectady Railway, was originally operated with direct current, the use of which is still continued within the city boundaries, while beyond them alternating current is now available. Two trollies are fitted to each car, that for direct current being of the usual pattern, and that for alternating current is of special construction which seems to be well adapted to high potential operation both electrically and mechanically. It also lends itself to the requirements of railways in which local traffic is conducted by motors, and through traffic by steam locomotives. The trolley wire and insulators are situated so that they are not exposed to the corrosive influence of smoke and gases from the funnels of locomotives, and the wire is hung low so that bridges need not interfere with operations. Hence it will be seen that the system, as exemplified at Schenectady, is particularly suitable for experimental installations. To obtain the full advantages promised by the employment of alternating current, energy should be transmitted from the generating stations at 30,000, or 40,000 volts, and transformed at sub-stations to the pressure of 2,000 or 3,000 volts. The transformer stations involve much less capital outlay than those for direct current; and, requiring little attendance, several of them can be placed under the charge of one man. In entirely new undertakings the most desirable plant would be one for the generation and distribution of single-phase current; but, in view of the large number of three-phase power stations already in operation, the General Electric Company have adapted the design of their new motor and of the distribution system so that they may be worked from any existing generating station.

The type of car used on the Ballston extension, when complete with motors and equipment, weighs 30·4 tons, empty; and has a seating capacity for 44 passengers. The car body measures 43 ft. over all, being mounted on two trucks, each carrying two compensated motors of 50 h.p. These motors are permanently connected, two in series, and are fed from the 400-volt secondary of a step-down transformer carried on the car. From an examination of diagrams taken by the General Electric Company, it appears that the speed-torque characteristics for alternating current are quite as well suited to the requirements of railway service as those given by direct-current motors. The speed of the compensated motor varies with the load; and, in consequence, the new machine should show to advantage as compared with the polyphase induction motor, which has constant speed characteristics. Comparing the performance of the new motor with alternating and with direct current, the following points may be noted from a set of curves based on a series of speed-time runs made on the Ballston line. When using alternating current, the rate of acceleration is less than that given by direct current, and the volt-ampere hours per ton-mile are higher. But the excess in question would be much reduced, if not entirely eliminated with increase in the length of run. The speed-time trial runs at Schenectady only covered a length of 1·6 miles, and scarcely afford a fair criterion as to the capabilities of the new system. Future performances on the Ballston line should be keenly watched by railway engineers in this country, as the complete success of the system will serve to demonstrate the suitability of single-phase traction for all the purposes of main-line traffic, quite apart from its value in tramway extensions to the country districts surrounding cities and large towns.

British Patent Laws.

WHILE the presidential address delivered by Mr. Parsons to the engineering section of the British Association is open to criticism, it nevertheless has the useful effect of calling further attention to the disabilities of British patentees. No doubt it is the case that various inventions, the importance of which is now demonstrated beyond all question, might have been developed far more rapidly if legislative aid had been forthcoming. Mr. Parsons shows that the financial side is a very important factor in securing success; but, as in the case of the internal-combustion engine, he admits that much hard labour is always necessary, and that the collective genius of many minds is frequently required for the complete development of an invention. Pursuing the proposal to its logical conclusion, we arrive at the idea of a State-supported research committee, the result of whose labours would naturally be public property, which can scarcely be the end desired by Mr. Parsons. A more practical demand is for extension of the time during which patents remain in force; but it is clear that the general prolongation of the existing term might become injurious to the trade of the country. No doubt the commercial realisation of some inventions occupies many years, and those who are occupied in the work may sometimes find the present term of 14 years has gone by before any serious attempt can be made to recover the money laid out in preliminary operations. Even then a further period of 14 years can be secured under existing regulations, and it must be admitted that 28 years is a fair slice out of any man's life to be devoted to the prosecution of one idea. Section I. of the Patents Act of 1902, to be brought into operation on the 1st of January, 1905, provides for search as to the novelty of inventions, and abolishes one grievance to which Mr. Parsons calls attention. Unfortunately, however, letters patent will still be granted in the absence of novelty, and the new rule requires further amendment before it can be regarded as satisfactory. Another matter of much importance is the necessity for affording protection against foreign owners of British patents, who deliberately abstain from utilising them, and are thus enabled to flood this country with foreign-made goods against which home competition is barred. We clearly require provisions for the revocation of patents that are being used in this manner, and the protective regulations adopted by Austria, Belgium, Denmark, France and Germany are certainly deserving of imitation. At present the wily foreigner is using our patent laws to injure British trade, while carefully guarding himself against reprisals on our part. This point is one that we are glad to find is now under consideration by the Tariff Commission.

Gas Engine Research.

SINCE the days of Lenoir, when the gas-engine first became a commercial success, continued improvement has been made in the design and construction of internal-combustion motors, and as Mr. Dugald Clerk showed in the "James Forrest" lecture this year,* the efficiency of such engines has been greatly increased during the past twenty years. We may now say that gas-engine design is entering upon a new phase; for, although the general thermodynamics of the internal-combustion motor are generally understood, precise data are still lacking as to the physical and chemical properties of gases at high temperatures, and further inquiry has still to be made into the phenomena of combustion. The heat efficiencies of internal-combustion motors have been increased from 15 per cent. to 30 per cent., since 1882, and it is quite certain that they can be further augumented when more knowledge has been acquired. One of the first points demanding attention is that of the specific heat of gases entering into the chemical action of combustion at temperatures ranging from 500 degs Cent. to 2,000 degs. Cent. No reliable determinations have hitherto been made at such temperatures. The results obtained by various French physicists are

*ENGINEERING REVIEW, Vol. X., p. 303, and Vol. XI., p. 50.

not altogether satisfactory, but welcome light upon the subject may be expected when the experiments now being conducted by Prof. Dixon are completed. Prof. Dixon has been studying the phenomena of combustion for many years, and we have recently published an account of some conclusions derived from his valuable researches.* More exact knowledge is required as to flame temperatures, the determination of which presents considerable difficulty. Further data will probably be obtained before long, and in the meantime it is interesting to note that, as the temperatures attained in internal combustion engines never exceed 2,000 degs. Cent., questions of the dissociation of gases do not come within the province of the gas-engine designer. The Paper read at the British Association Meeting by Mr. Dugald Clerk, reprinted elsewhere in this issue, deals with the general question of flame temperature, and particularly with the results of experiments made by the author with the object of securing lower and more constant temperatures in the cylinders of internal-combustion motors, by diluting each charge of explosive mixture with compressed air or compressed gases from the exhaust. Mr. Clerk describes two kinds of engine in which his latest idea has been incorporated, and shows that, in one example, where compressed air is introduced, the temperature after explosion was reduced from 1,700 degs. Cent. to 1,200 degs. Cent., with an accompanying increase of thermal efficiency of 6·7 per cent.; and in the other, where exhaust gases were employed, the temperature after explosion did not exceed 1,200 degs. Cent., while the heat efficiency was increased by fully 20 per cent. These are valuable results, and demonstrate the possibility of obviating to a large extent the difficulties and disadvantages attending the use of the high temperatures hitherto prevailing in gas-engines.

Steel.

OUR contemporary, *The Engineer*, in its issue of September 7, devotes an editorial to the mystery of steel. Inspiration has been found in Professor Arnold's recent paper before the British Association, further fruitful matter having been discovered in Mr. Stead's discussion on Heyn's paper (1) and in the "animated, not to say, acrimonious discussion" (2) on the sixth report of the Alloys Research Committee.

The conflicting views of Messrs. Arnold and Stead are dwelt on, but as the editorial expresses no opinion relative to heat treatment we do not propose to follow this somewhat historical matter. We note, however, that in one case our contemporary does express an opinion, and terms it a reason.

A perusal of Professor Arnold's paper will show that he has opened out a new field of metallurgical research, viz., the detection of a type of brittleness not evidenced in the usual tensile or bending tests. In the course of a lengthy investigation Professor Arnold has examined the case of a boiler, the shell plates of which split longitudinally from end to end under hydraulic test. The results of many tests show one side of this boiler-plate to be brittle and the other tough under alternating stresses.

Our contemporary cannot accept these results because the "boiler-plate had not been subject to any dynamic stress whatever," and herein fails to grasp the purport of Arnold's work. However, though the purport of this work is not realised, a reason is readily supplied to explain the cause of this particular fracture. For instance, we read :—

> "The reason why Mr. Milton's plate cracked must, we hold, be sought in a different direction. The phrase used by Professor Arnold, 'split like glass' is suggestive. It is not impossible that a fine hair crack of the right kind was developed during the construction of the boiler, and that under the test the crack ran as cracks will run. We are not aware of the existence of any microscopic research as to the nature of cracks. We have a sound end of a plate, say of glass, and a cracked end. Just where the crack meets with the sound portion is the crucial point, and we fancy that very strange and interesting information as to the molecular arrangement and action and

*ENGINEERING REVIEW, Vol. XI., p. 145.

(1) On the Over-heating of Mild Steel, *Journal of the Iron and Steel Inst.*, 1902. No. II., p. 137.

(2) *The Engineer*, Sept. 7, 1904.

interaction would result from an inquiry into the whole subject; such an inquiry is, however, surrounded with difficulties of observation, and for this reason, perhaps, it has not been taken up."

The latter portion of this somewhat cumbersome quotation is very true. Such an inquiry *is* surrounded with difficulties, and the first will be found in producing cracks having an influence on the *molecular* arrangement. However, we are for the moment, concerned with a boiler which fractured under hydraulic test, the cause being due, *vide Engineer*, to "cracks." The plates of this boiler were 1 in. thick, and weighed about 3 tons. The fracture followed one route, apart from which no other cracks are described. Portions of the plate tested by Professor Arnold show one side to be brittle and the other tough under alternating stresses. The test pieces used are $\frac{3}{4}$ of an inch square by 6 ins. in length, hence the two sides of a 1-in. plate may be readily tested.

There are then two features of note, *a*, the difference in quality between the two sides of these particular plates, and *b*, our contemporary's statement that the failure is due to cracks. Let it also be noted that the many test-bars examined would necessarily represent a comparatively large area of the plate.

Therefore if *b* is correct, the cracks must necessarily be distributed uniformly on *one* side of the plate only. Evidently cracks of this type do not segregate.

But the crack theory, if at all plausible, should influence adversely the tensile tests. We therefore turn to Professor Arnold's figures and note the following:—

Elastic Limit. Tons per sq. in.	Max. Stress. Tons per sq. in.	Elongation % on 2 in.	Reduction of area %
15	29	29	50

Are we then to conclude that a mild steel which stretches 29 per cent. on a length of 2 ins., showing a contraction of area of 50 per cent., fails on hydraulic test owing to the presence of cracks?

Finally, we are tempted to think that the "reason" so glibly advanced by our contemporary in reference to one particular instance of what is admittedly the most difficult problem of steel metallurgy, savours somewhat of the nature of "cracks."

Smokeless Steam Coal.

A SOMEWHAT unequal controversy has been raging in the columns of *The Times* during the last two months, and has raised echoes among various journals more or less interested in the coal trade. The controversy may fairly be described as unequal, because on one side stands Professor Boyd Dawkins, an eminent geologist who is obviously disinterested in his contention that we are not dealing wisely with smokeless steam coal which, properly conserved, would go far to give us the mastery of the sea; while on the other are those who are directly interested in selling as much as they possibly can of the national inheritance. It is admitted, even by South Wales colliery owners, that our smokeless steam coal will not last more than one hundred years at the present rate of output. But, as the rate of production will almost certainly continue to increase as time goes by, it is not impossible that the supply may come to an end within sixty or seventy years—a very short time in the history of a nation. No reliable opinion can be formed on this point until the investigations of the Royal Commission on Coal Supplies have been completed, and there is every reason why the Government should immediately refer to that body for guidance. If it should be demonstrated that we are actually approaching the end of our supplies of Welsh anthracite, all who appreciate the paramount importance of maintaining the maritime supremacy of Great Britain, will agree that the remaining store, or a sufficient portion thereof, should be religiously conserved for national purposes. In any event, a heavy export-duty might be placed on smokeless coal without injury to the trade, for foreign navies must buy this fuel, and, as recent events show, would continue to buy it at greatly augmented prices. As a nation, we are lavishly generous to the foreigner. We admit his manufactures free of duty, and, possessing a monopoly in Europe of smokeless steam

coal, we export it free, even to nations by whom it is employed for the purpose of preying upon our own shipping. The negotiations now in progress for the acquisition of certain coal-mines by the Prussian Government afford one more indication of the watchful care bestowed by the rulers of foreign countries on matters that concern the future of great national interests, a policy which, unhappily, finds too little support in our own Parliament.

The Panama Canal. American Fiscal Tactics.

No decision has been announced up to the present upon the question whether the United States Government will undertake the construction of the Panama Canal by direct labour, or will invite tenders from contractors for the execution of the work. Before any definite action is taken, the report of the commissioners recently sent to Panama must be considered, and all the details of the project worked out by the technical staff of the Canal Commission. It is probable, therefore, that no work upon the canal itself will be commenced for several months. Nevertheless, a large amount of preliminary work in the Canal zone will be undertaken at once, and for this considerable purchases of material are on the eve of being made. The chief items of work include the repair of some 2,000 existing buildings—including offices, storehouses, hospitals and residences—the sanitation of towns and villages, and the establishment of water-supply systems on an extensive scale. Unfortunately for British manufacturers, measures have already been taken to make the prospective trade a close preserve for the United States by the application of the Dingley tariff to all goods imported into the Canal zone, except those coming from the United States. The effect of this smart manœuvre will practically insure the purchase in the United States of all preliminary supplies, and ultimately of all the machinery and materials required for the construction of the canal as well as for the maintenance of the staff and men engaged. Mr. Roosevelt's recent utterances show that he fully appreciates the immense value of protection to the United States, and this latest example of tariff-wall building should go far to drive common sense into the heads of those in this country who still cling to Utopian ideas of universal free trade.

Mechanical Grabs.

In an article to be found elsewhere in the present issue of The Engineering Review, Mr. Henry E. P. Cottrell gives an interesting account of some forms of machinery for the economical handling of material removed during the execution of important engineering works, or for moving heavy and bulky substances of all kinds from place to place. His attention is chiefly directed to the consideration of those ingenious appliances generally known as grabs, or excavators. While machines for assisting the engineer in dredging operations have been in general use for centuries, and probably in simple forms for thousands of years, the adaptation of the grab to the mechanical handling of material, as apart from dredging and excavation, is a distinctly modern development whose importance deserves full recognition in industrial as well as in engineering circles. As Mr. Cottrell shows, Wild's grab introduced about 1883, marked the first step towards the employment of such apparatus in the manner indicated. By the introduction of the Hone grab, however, a most convenient and economical means was provided for dealing with coal, coke, ore, lime, cement, sand, grain, manures and various substances, in addition to those incidental to civil engineering contracts. Satisfactory evidence of the utility of the Hone grab is to be found in its extensive use by the largest gas and coal companies, cement manufacturers, and other industrial companies and firms. As a matter of fact, the saving to be effected by mechanical, as distinguished from hand, handling is as much as 4*d.* per ton in the case of coal and materials of similar

character. For the rapid and economical removal of material in connection with harbour and dock works, the contracting engineer finds the grab an indispensable aid. The first large appliance of the Hone type, built for Sir John Jackson in 1895, was employed upon the Dover Harbour contract, where its efficiency was so completely established that many others have been supplied for the same works, as well as to Admiralty contracts in various parts of the world. The Hone grab made for Messrs. S. Pearson & Son in 1898, and used on the Dover Harbour works, is the largest of its kind in the world. It forms one of a set of five similar machines, the capacity of which varies from 100 cub. ft. to 150 cub. ft. of material. For full details as to the different types of grab now available, we must refer our readers to the article by Mr. Cottrell, who gives diagrams and tables, containing much practical information that cannot fail to be of service to civil engineers and contracting firms. Notwithstanding the objection entertained in some quarters to the supersession of manual labour by mechanical appliances, it is now recognised that grabs and excavators permit many works to be undertaken that would be well-nigh impossible by ordinary means, and so conduce to the well-being of both masters and men. Moreover, the facilities offered by machinery of the class described form a direct encouragement to enterprise in various directions which ultimately leads to the benefit of the entire community.

Turbine Steamers on the Irish Channel.

In an article which appeared in the September issue* dealing with Heysham Harbour and the new Midland route to Ireland a brief description, accompanied by an illustration, was given of one of the four new steamers now operating that service. We are now, however, in a position to supplement the details given therein by some information concerning the propelling machinery that has been fitted in the boats in question. The selection of this has been made with great care, and will place the company in a position to make exhaustive trials to determine the relative efficiency of the marine turbine and engines of the reciprocating type.

The first-class results obtained with the turbine in some of the lighter class vessels of the Royal Navy suggested the suitability of propulsive machinery of this type for light passenger vessels, and the success attained in cases of the s.s. *King Edward* and the s.s. *Queen*, fully justified the Midland Co. in similarly fitting two of their new high-speed boats—viz., the *Londonderry*, built by Wm. Denny & Bros., and the *Manxman*, constructed by Vickers, Sons & Maxim. Both these vessels have been fitted with three shafts driven by separate turbines. The others—viz., the *Antrim*, built by Messrs. John Brown & Co., Ltd., and the *Donegal*, by Messrs. Baird & Co., are twin-screw vessels driven by triple-expansion engines with cylinders 23, 36, and 42 ins. diameter, respectively, by 30-in. stroke. All of the vessels are of the same dimensions—viz., length 330 ft., breadth 42 ft., depth to upper deck 18 ft. Due to the lighter weight of the propelling machinery, an advantage is gained in the case of the turbine vessels in respect of displacement, which is only 2,400 tons, corresponding to a full-load draught of 13 ft., as against 2,600 tons, corresponding to a draught of 13 ft. 6 ins. in the case of the vessels fitted with reciprocating engines. The full load, be it mentioned, is 300 tons dead weight, 180 first-class passengers and 80 second-cabin passengers. In all four cases steam is supplied from two double and one single end Scotch-type boilers; the working pressure, however, differing to enable a test being systematically carried out with the object of determining whether any increased efficiency is to be obtained from using high-pressure steam for turbine working. On the *Londonderry* the pressure has been fixed at 150 lbs., on the *Manxman* at 200 lbs., which latter is the initial working pressure on the reciprocating engine vessels.

It will thus be seen that very unusual facilities are afforded for comparing, not

* Cf. pages 216–221.

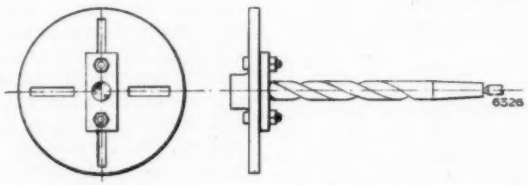
only the relative efficiency of turbines *v.* reciprocating engines, but in the working of two turbines running under conditions differing only in the case of initial steam pressure. The arrangement of the turbines is the same as that adopted by Messrs. Parsons on all vessels previously fitted by them. The high-pressure turbine operates the centre shaft at a speed of 600 revolutions, a low-pressure machine driving each side-shaft at a speed of 500 revolutions. A saving in weight has been effected in the design of the shafting, the diameter for the reciprocating-engine shafting being 12 ins., while that on the turbine is only 8 ins., corresponding to a saving of about 45 per cent. Only one propeller has been fitted on each shaft of the turbine steamers instead of two or three as in former cases, thus permitting of a simpler hull construction. Go-astern turbines are placed in the back casing of the low-pressure turbines. Special attention has been paid to the question of terminal pressure. On the *Manxman* a special vacuum augmenter, consisting of a steam-nozzle fixed at the base of the air-pump, and in the *Londonderry* a supplementary Weir air-pump have been installed. Beam type air-pumps of the independent pattern have been installed on the reciprocating-engine boats. As in the case of the main engines, the same plan has been adopted in connection with the auxiliary electric-lighting plant, which on the *Londonderry* is driven by a Parsons turbine, and on the *Manxman* by a de Laval turbine.

The question of propeller efficiency will be necessarily involved in any comparison between these ships as to speed, because, as is well known, it is impossible to indicate turbine engines. It is expected that the results obtained from the trials will afford useful data in connection with the best design of propeller suited to the high revolutions of the turbine engines.

Turning Twist-Drill Shanks.

ONE of the most common causes of failure of twist drills is the driving portion of the shank end twisting off, which necessitates a fresh taper being turned further on the drill. In shops where universal chucks are not so common, and grinding machines not in use, it is not an easy matter to mount a twist drill between the centres of a lathe and drive it true; the illustration shows a simple method of solving the difficulty. It consists of a rectangular piece of iron of convenient size bolted across the face-plate as shown, the centre being removed to permit this. The lathe is then started, and a drill point pushed against the iron block and held firm, which produces the true hole. The drills to be turned up are then mounted in this chuck, the other end being centred in the usual way, and when forced tight up they will drive for turning without any "driver" or dog, the friction of the cutting-edges at the point being sufficient for that purpose. J. G.

[Taper chucks, 1 in 20, are excellent for the same purpose.—ED.]



TURNING TWIST-DRILL SHANKS.

Piney Creek Trestle Bridge on the Tennessee Central Railroad.

(Communicated.)

THE Tennessee Central Railroad, the headquarters of which are at Nashville, was pushed forward in both directions from the town of Emory Gap, on the line of the Queen and Crescent Railway, as rapidly as the erection of the bridges permitted. There are four trestle bridges, viz.—(1) that over the coke ovens of the Roane Iron Company; (2) that spanning the Big Gulch; (3) that on the Millstone branch; and (4) the longest, the Piney Creek Trestle, which is shown, both in course of erection and completed, by the accompanying reproductions of photographs, taken by Mr. George W. Morgan, of Harriman, Tennessee.

The bridges were designed by the consulting engineers for the Tennessee Central Railroad, Messrs. Waddell and Hedrick, both of whom are members of the Institution of Civil Engineers, and also of the American Society of Civil Engineers. Mr. Waddell, who is recognised as one of the foremost engineers for railway bridges in the United States, is the author of several works on the subject; and the specification for the Tennessee Central Railroad bridges provides that a chapter of his treatise "De Pontibus," shall be considered as part of such specification.

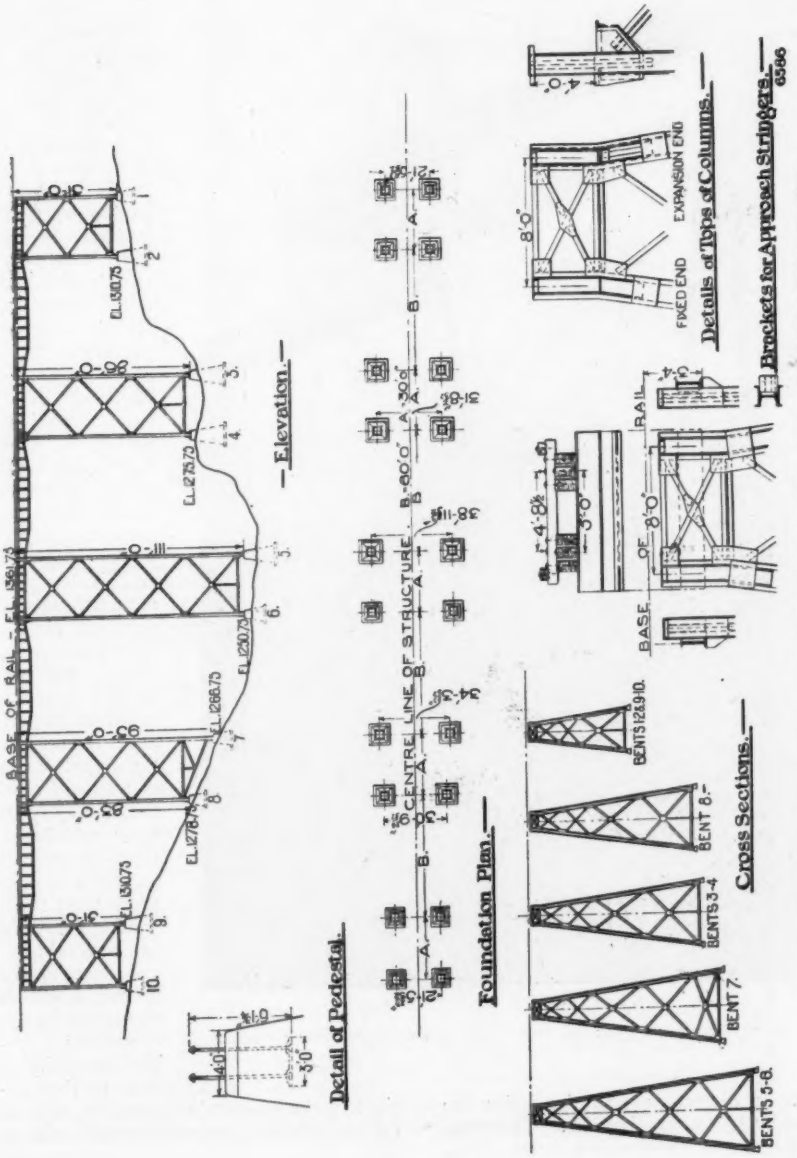
In this valuable work, Mr. Waddell observes that the best lay-out, or design, for a trestle bridge is that which will make the cost of the structure a minimum, provided the specification ensures the requisite strength and rigidity, when the cost of the towers and their pedestals is equal to that of the longitudinal girders and bracing; and on this account it is advisable to make the tower spans shorter than the intermediate, though not too short for appearance or resistance to traction.

In the bridges under notice, the tower spans are 30 ft., and the intermediate 60 ft. Mr. Waddell's reason for not exceeding these spans is, that trestle bridges are nearly always erected by starting from one end and dropping the members down from an overhanging traveller running on the top of the erected portion, as shown by one of the photographs. With these spans the travelling crane has to reach out 90 ft., which is about the extreme practical limit.

Mr. Waddell also recommends that the longitudinal girders abut against and be riveted to the webs of the columns, the latter being bent just below the longitudinal girders when the legs are battered, while he considers that it is not worth while to adopt a batter of less than $1\frac{1}{2}$ in. to the foot, and never economical to adopt one greater than 3 ins. As will be seen by the general drawing, the side batter adopted for the trestles in the Piney Creek bridge is $1\frac{1}{2}$ in. to the foot. The boxed spaces at the column feet are filled, after painting, with Portland cement grouting, the standard proportion of which is one part of cement to two of sand; but when the spaces to be filled are large the addition is admitted of two parts gravel or finely broken stone.

The structural material of which the trestles are built up, is steel of medium hardness; and the reason for using this metal almost entirely, to the exclusion of mild steel except for the rivets and adjustable members, is that, for the same cost of raw material, medium steel is quite 15 per cent. stronger than the mild variety, while being just as trustworthy and satisfactory. As to the advantage claimed for mild steel, that it requires no reaming, Mr. Waddell regards this as a fallacy, because, in order to obtain proper matching of rivet holes in the various component parts of a bridge, reaming is a *sine quâ non*. The mild steel rivets are

GENERAL VIEW OF THE PINEY CREEK TRESTLE BRIDGE, TENNESSEE CENTRAL RAILROAD.



LOCATION PLAN OF FOUNDATIONS AND METAL WORK, PINEY CREEK TRESTLE BRIDGE, TENNESSEE CENTRAL RAILROAD.

PINEY CREEK TRESTLE BRIDGE: THE OVERHANGING TRAVELLER DROPPING A GIRDER.

$\frac{7}{8}$ in. in diameter; and the holes are generally $\frac{1}{16}$ in. in diameter. The shop and field rivet holes were punched $\frac{1}{8}$ in. smaller than the diameter of the rivets, and reamed to $\frac{1}{16}$ in. larger.

In respect to the painting of structural steel, engineers as a body appear to be unsettled in opinion, each one having a pet paint of his own or experimenting in a haphazard way to find one, observes Mr. Waddell; and the following is his conclusion on the subject, expressed in a paper on Elevated Railroads before the American Society of Civil Engineers:—"In short the engineering profession is all at sea on the paint question, and is likely to remain there until some original investigation is made; but the subject is one of sufficient importance to warrant the appointment of a special committee to experiment and investigate on the subject for a term of years until some valid conclusions can be reached."

A practical step in this direction was taken by the consulting engineers specifying that, as they desire to make large-scale comparative tests of certain standard protecting materials, they had decided to adopt graphite, carbon, and silica graphite paints for the first three bridges above named, and carbonising

coating on the Piney Creek Trestle, while enjoining that the various makers' instructions be implicitly followed in order to secure the best results.

Carbonising coating is the natural chemical union of carbons, linseed oil and red oxides, each ingredient being taken in the chemically pure state and left in tanks exposed to the open air for four months, during which period the chemical union takes place, there being no separation of the particles no matter how long the material may be left to stand thereafter. The ingredients are combined in such proportion as to give the greatest amount of protection to the vehicle or binder, while at the same time affording the maximum covering capacity. In other words the vehicle is loaded to an exact nicety with the pigment used, so as to produce an absolutely impervious paint, while securing great economy owing to the high covering capacity.

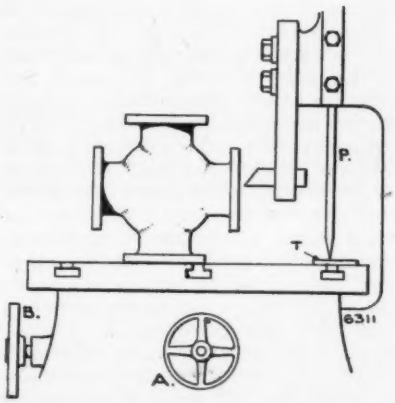
It is claimed that carbonising coating, which is made by the Goheen Manufacturing Co., Canton, Ohio, hermetically seals the pores of the metal, and thus protects it from all known corrosive agents, being unaffected by smoke, coal gas, steam, sulphurous acid, ammonia fumes, sewer gas, mine water, the drippings from cold storage cars, and many other agents that readily destroy ordinary paints. Two coats, with an interval of eight or ten days between, are required to afford thorough protection; and when these are properly applied the company guarantees their duration, without the necessity of repainting, for a period of seven to ten years. The Piney Creek Bridge received three coats, applied by hand, the first in the shop, the second during erection, and the third after completion, while recent reports state that the paint is in excellent condition.

The bridge was erected by the Carnegie Steel Co., Ltd., at whose Keystone Bridge Works, Pittsburg, Pennsylvania, the parts were also machined.

MACHINING HOLLOW FLANGES.

THE fitting of boiler mountings, valves, etc., having hollow flanges, necessitates at times a great amount of chipping through the inequalities of the casting or variations of radius during the cooling of the casting. The correct radius may be produced and a great amount of labour saved by bolting the valve or mounting to the table of a slotting machine as shown in the illustration. A piece of plate-iron *T* is then clamped to the machine table, the required radius of the flange being scribed upon it previous to setting in position. A pointer *P*, made of iron, is then fixed to the side of ram-slide over the screws used for tightening up, the loose strips being utilised for the purpose. The rotary feed *A* is then put in gear and the traverse *B* manipulated by hand to keep the pointer on the scribed line marked on the templet. Excellent results are obtained by this method. J. C.

[The pointer should be cranked in order to stand central with the slotting tool.—ED.]



Fire-Resisting Construction.—III.

By W. NOBLE TWELVETREES, M.I.Mech.E.

In this country the use of armoured doors is chiefly limited to the interior of large buildings, to check the spread of fire from one part to another. It is extremely desirable, however, that similarly built doors should be employed in the outside walls to prevent the communication of fire from adjoining or adjacent buildings, and it is equally necessary that windows should be provided with fire-resisting shutters, of which several varieties are manufactured; and in the most efficient types apparatus is fitted, designed so that the shutters will automatically fall when the temperature has risen beyond a certain point. Fig. 23 shows a type known as the Kinnear Rolling Shutter, which is equipped with an automatic closing device, which operates at a temperature of 150 degs. Fahr., and the curtain is released by compound levers so arranged that they are positive in action, and respond immediately to the separation of a fusible link suspended in the centre of the opening. Tension springs are provided, giving an impulse which causes the shutter to descend rapidly as soon as released by the melting of the fusible metal. The detail of the arrangement shown in the illustration has, however, recently been improved by doing away with the bevelled gear for rewinding, and making the shutters so that after the spring is released, and they are closed automatically, sufficient tension is retained in the barrel to cause the steel curtain to recoil when it is raised from the bottom. The small spiral springs shown attached to the angles and grooves are also not now required. These shutters are accepted by the fire-insurance companies of the United States, and are widely used, not only for the purpose of protecting window and other exterior openings, but for communications in elevator shafts. Recent experiences, particularly in America, have shown their importance in preventing fire passing from window openings across intervening streets and so obtaining access to other buildings.

Armoured glass may justly be described as one of the most invaluable aids in fire-resisting construction, as experimental and practical tests show that it is capable of withstanding very considerable shocks, strains, and high temperatures without fracture. This material is consequently most useful as one of the defences of a building against attacks from without.

It is well known that the heat radiated from a burning building is so intense in the immediate vicinity, that the panes of glass in adjoining structures are readily cracked and fall out, although they may not be touched by the flames. The open window creates a strong draught, the fire attacks the window frames and inflammable interior, and rapidly spreads to the whole building. The special function of the electro-glass made by the British Luxfer Prism Syndicate is to resist the effects of flame and heat, to keep fire from entering buildings as well as to retard its progress in buildings in which fire had broken out, and even to stay in position when a stream of water is thrown upon it. Figs. 24 and 25 show to some extent the resistance offered by this system. Fig. 24 is reproduced from a photograph taken before a fire; Fig. 25, from one taken after the plate had been made red hot, and then suddenly cooled by a stream of cold water. Although showing cracks in every direction, it nevertheless held together with great rigidity. As electro-glazing does not fall out, it helps to confine the fire to a single room, and keeps that room so close that the fire can burn but slowly. This confinement of the air by fire-resisting windows is one of the best possible safeguards against fire, but it is necessary that the electro-glass should be used not only in all exterior windows, but also in all interior partitions in which windows are required.

Electro-glass should be used as a screen around every lift-shaft, entirely enclosing the shaft from top to bottom; while the light is still permitted to enter the shaft, the dangerous openings from one floor to another are entirely shut up, and the floors isolated by this fire-resisting screen. Stairways should be enclosed by a screen of electro-glass so as to stop the spread of fire from floor to floor, thereby enabling their occupants to escape, and giving the fire brigade every opportunity of extinguishing the fire at its earliest stage.

A useful fire-resisting material recently introduced is known as Calmon's Asbestos-Slate. This is produced in sheets measuring 40 ins. by 40 ins., and from $\frac{1}{8}$ in. to $\frac{1}{2}$ in. thick. It is supplied in two qualities—"S" being for walls and roofing, and "C" for roofing only. Asbestos slate can be obtained in various colours, as white, slate-grey, green, and brick-red, or enamelled to imitate ornamental stone for the interior linings of public buildings, or enamelled white for cabin panels and fittings of steamships. Insulating cable casing, of $\frac{3}{4}$ in. grooved slate, is a special form of the same material, and is being largely used in connection with the electrification of the Metropolitan Railway. Among the advantages claimed for asbestos-slate are its high resistance to fire, water, and electricity, its high mechanical strength, and the readiness with which it can be worked by ordinary carpenter's tools, and fixed in position by ordinary nails or screws. As showing its adaptability for the rapid construction of fire-resisting buildings, we reproduce in Fig. 26 a photograph of a bungalow, in which the walls and roof are entirely covered with asbestos-slate. This material appears to be an admirable substitute for quarry slates, tiles, corrugated iron, asphalt, and particularly for the combustible materials so largely used in the construction of light and temporary buildings.

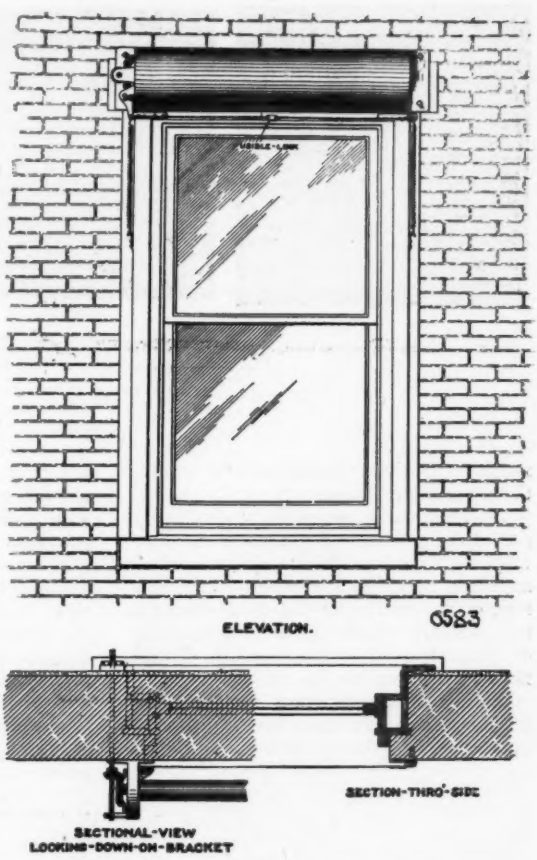
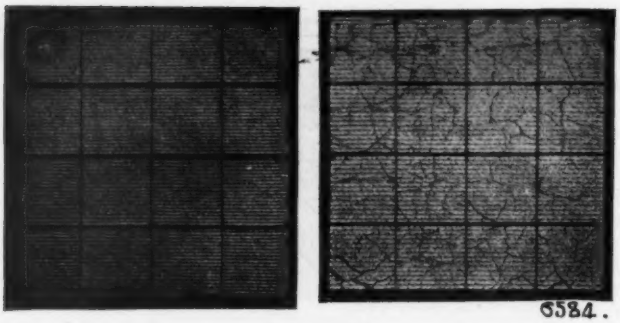


FIG. 23.—DETAILS OF A KINNEAR AUTOMATIC ROLLING SHUTTER.

Having dealt with the main structural features of buildings from the point of view of fire-protection, we now direct the attention of our readers to the advantages presented by the use of non-flammable



APPEARANCE BEFORE A FIRE. APPEARANCE AFTER BEING MADE RED-HOT AND SUDDENLY COOLED.

FIGS. 24 AND 25.—FIRE-RESISTING GLASS MADE BY THE BRITISH LUXFER PRISM SYNDICATE.

materials for the construction and decoration of interior fittings.

Non-flammable wood is undoubtedly one of the greatest safeguards in modern building construction. Unless other approved materials are employed its use should be made imperative as a substitute for ordinary timber in the construction of staircases, lift casings, roofs, doors, floors, partitions, screens, and furniture.

Authentic records show that valuable buildings have been saved from destruction by the use of wood treated so that it is rendered incombustible in the ordinary sense of the term, and the official reports of the British Fire Prevention Committee are conclusive as to the resistance of this material. As the result of a severe test conducted by the committee in July, 1899, it was found that no incandescence or spread of flame was observed; nor did the material, as far as could be seen, contribute in any way to the spread of flame. It should be noted that in this test, flame was applied at materially higher temperatures than those specified. The temperatures rose in the first stage to about 1,000 degs. Fahr.; in the second stage to about 1,150 degs. Fahr., and in the third stage to about 1,300 degs. Fahr., the only effect being that the surface of the boards was charred.

A most useful development is to be found in the application of the process to canvas, gauze, muslin, plush, and the most delicate fabrics of all kinds, so that they can be rendered non-flammable, thereby placing still another weapon in the hands of those whose business it is to protect buildings and their contents from fire.

FIG. 26.—AN EXAMPLE OF ASBESTOS-SLATE CONSTRUCTION.

Another point to which attention should be drawn is the use of fireproof paints for preventing the inception and spread of fire. Such materials have been on the market for years, but in spite of this fact a large majority of those responsible for the design and erection of buildings of

all kinds still adhere to the old-fashioned forms of combustible and highly inflammable paints that have been in use from time immemorial.

This is all the more to be wondered at when it is possible to obtain asbestos fire-resisting paints in any colours and for inside or outside use. In addition to giving a thoroughly fire-resisting protection, they have all the advantages of a first class oil paint both in colour and finish.

The action of fire on ordinary paints is to melt and soften them, so adding the inflammable matter to the flames; on the contrary, asbestos fire-resisting paints, such as those, for example, manufactured by the Asbestos Fireproof Paint Co., Ltd., stiffen and form a metallic air-tight covering round the woodwork, thus effectually preserving it from the flames.

The following is an extract from a report by Professors Bondin and Douney, of the University of Ghent, made by order of the Belgian Government on the asbestos fireproof paint manufactured by the Asbestos Fireproof Paint Co. The report states that:—

> The structure painted with this material resisted internally the action of an energetic and prolonged fire of four successive charges, and it resisted in a manner nearly absolute, seeing that the four charges weighed about one-fifth of the structure. The structure at first gave out some small flames, due to the release of resinous gases, but there was no spreading of the fire. The first charge burnt for five mins., the second seven, the third three, and the fourth six, the firing lasting 21 mins. To give an idea of the efficacy of this mineral, and the heat developed by the combustion of the four charges, which it has resisted, we made an experiment of which anyone will immediately appreciate the value.
>
> In the central space of a structure composed of pieces of wood painted with asbestos fireproof paint, we made a fire, fed by continual additions of wood and live coal. The heat developed was such that we were able easily to cook successfully in a little frying-pan an egg, two pieces of meat, weighing respectively 34 and 17 grammes after cooking, and then a third piece weighing 37 grammes before cooking. These operations took 25 mins., and the structure at the finish was in a perfect state of preservation, and had lost less than 2 per cent. in weight.
>
> This paint is best of all; it unites at once the properties of an excellent preservative substance and a good paint, well ground, of an easy application, good appearance, and of a relatively low price.
>
> The great feature claimed for this paint is that it does not in any way interfere with the structural strength or construction of woodwork used in a building, and at the same time gives all the necessary protection. The objection to some fireproof compounds on the market, is that they either seriously weaken the timber which they impregnate, or that the chemical nature is so strong as to injure brass or metal work that may be employed.

In conclusion, it may be remarked that comparatively few people are aware of the enormous losses that take place year by year in consequence of fires. The claims on British fire-insurance companies probably amount to fully £10,000,000 per annum, and the losses on uninsured property are estimated at about £4,000,000. In London alone there are nearly 4,000 fires annually, resulting in the loss of many lives and of property to the value of millions of pounds.

Most of the fires that afterwards develop into serious proportions would never spread far beyond the point of origin, if non-flammable hangings and furniture were used; and they would be confined to the rooms in which they start, if window and door frames, partitions, ceilings, and floors were properly constructed.

The perilous nature of ordinary building construction is already recognised by all intelligent structural engineers and architects, but the adoption of scientific fire-resisting design is still regarded as an unnecessary luxury by the great majority of property owners.

The object of this article is to show that fire-resisting design is imperatively necessary in the present day, that an immense variety of suitable materials is available for its realisation, and that fire-resisting construction represents true economy in every sense of the word.

Modern Appliances for the Economical Handling of Material.

(GRABS, EXCAVATORS, etc.)

By HENRY E. F. COTTRELL, A.M.Inst.C.E.

THE tendency of modern industrial development to replace manual labour to an ever-increasing extent by mechanical appliances wherever the conditions admit of this replacement is unmistakable. The causes of this tendency can readily be traced in at least two directions; the first, or employer's direction, being that of saving expenditure, the second, or employé's, being that of saving of exertion. No sooner is an industry organised on the modern scale of production than the economics of commerce in "bulk" have to be consulted, and every means of fractional saving have to be sought and adopted, so as to make the most of the slender margin of profit afforded to production under the modern conditions of more or less strenuous competition. Machinery of partly or wholly automatic character has to be used wherever the character of the work to be performed is such that the machine can be worked under economical conditions, *i.e.*, wherever the work to be performed is approximately uniform and continuous, and admits of the machine being worked over lengthy periods of time without stopping, and approximately at its maximum capacity. The organisation of industries for production on the modern scale which has initiated the epoch of what may correctly be called "commerce in bulk" has been accompanied *pari passu* by the organisation of labour on lines whose characteristics have been dictated by an increasing distaste for heavy manual labour, united to an increasing craving for leisure and amusement. The labour saving or replacing machine, so long as it relieved the employé of the heavier and more exhausting portion of the work to be performed, was always welcome, provided it did not interfere with the number of men employed and did not cut down prices; that is, provided it was not too automatic and the economy effected by the machine was, at least in part, credited to the men tending it, so that they would at most work the same number of hours for the same wage—(if they could not manage to work shorter hours with higher wages) and at a considerably diminished rate of exertion. It is when employers have insisted on keeping the lion's share of the profit involved in the use of labour saving machinery, and in cutting down the number of hands employed to the effective proportions demanded by the machinery, that trouble has ensued between masters and men. On the whole, however, the adoption of mechanical labour saving appliances in the case of work involving heavy manual labour is now in most countries limited chiefly, if not solely, by the financial capacity of the master, and to a more limited degree by the labour protectionist regulations of the men's unions. The more advanced of the unions in the U.S.A. practically recognise that manual labour can and ought to be replaced by mechanical appliances where the work to be done is continuous and uniform in character; while the masters admit that generally manual labour is both more suitable and more economical than machinery where the work to be done is discontinuous and varying in character. Where the two parties hold views which are practically identical, it is not difficult to hit upon the happy mean between hand-work and machine-work, and this explains *pro tanto* the superior advantages for industrial production existing in the U.S.A., as compared with Great Britain at the present time.

With us, and in most of the leading industrial countries of Europe, there can be no question as to the superior economy of machine handling, as compared with manual handling for heavy and bulky substances, such as coal, coke, ore, sand, gravel, cement, lime, manures, grain, etc., when the handling has to be effected in any considerable amount, so that in discussing the advantages of the application of special machinery to these services, debatable ground will not be trenched upon.

Shallow baskets of various materials were probably the earliest appliances used for transferring material reduced to the requisite degree of fineness from one level to another, and it is a very long cry in the history of mechanical improvement from the basket carried on men and women's heads or shoulders to the basket slung from the rope of a derrick or crane, which was soon replaced by the metallic bucket or skip with which we are still familiar. From skip to grab the stages of evolution which bridged the interval between an appliance which demanded the direct assistance of human labour both at the beginning and end of its cycle of work, to one which requires no direct assistance from human labour at all, are clearly enough marked.

a. Ordinary non-tipping skip or bucket.
b. Skip or bucket suspended from eccentrically placed trunnions.
c. Skip with hinged bottom.
d. Centrally divided skip hinged at top.
e. Centrally opening and closing grab worked by mechanical means.

The use of mechanical grabs, constructed more or less on lines resembling those with which we are familiar, was probably known by the Romans, who are supposed to have employed them in the excavation of some of their canal works (possibly even in England); and Sir Benjamin Baker has expressed the opinion

PRIESTMAN NO. 1 GRAB SHUT.

PRIESTMAN NO. 1 GRAB OPEN.

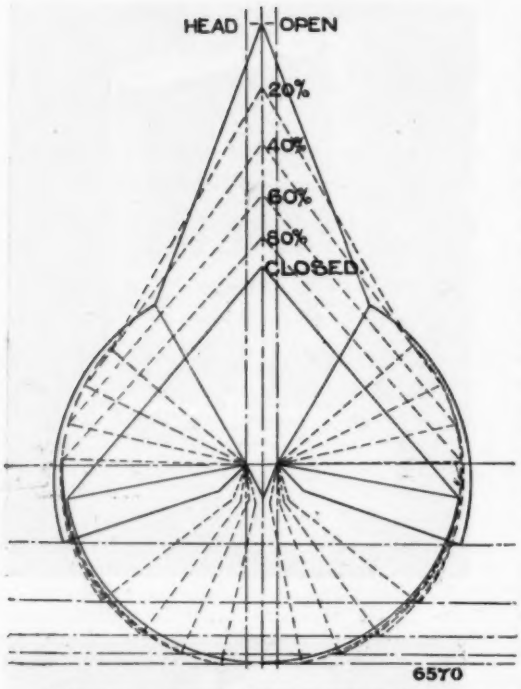


DIAGRAM NO. 1.—PRIESTMAN DREDGER (TYPE NO. 1), SHOWING MOTION DURING CLOSURE ABOUT THE BUCKET HINGES.

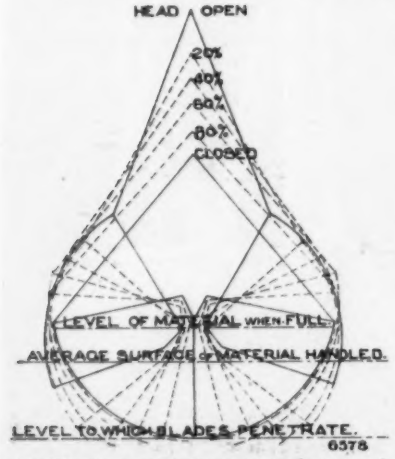


DIAGRAM NO. 2.—PRIESTMAN DREDGER (TYPE NO. 1), SHOWING MOTION DURING CLOSURE ABOUT MATERIAL HANDLED.

that grabs were used in the excavation of the first Suez Canal (about 500 B.C.). The immediate progenitor of modern grabs was, however, the excavator invented by a French engineer, M. Gouffé, in 1703: this was worked by a double-rope suspension, and used for excavating under water, and was provided with tynes or serrated edges. The Jham Spoon Dredger, used for centuries in India and in the Mediterranean for excavating the foundations of bridges in torrential river bottoms and for clearing banks of sand, etc., in streams and in harbours, was the progenitor of some early forms of "dredger-grabs" used in Indian Public Works by engineers like Ives, Gattnel, and Millroy, and have also been used at home for bridge pier sinking, etc. The Clamshell Dredger, invented in the U.S.A. and introduced in this country about 1870, was the earliest grab, properly so called, which was regularly used for well-sinking and dredging operations to a relatively considerable extent with very satisfactory results. The first grab produced in Great Britain for excavation, etc., under water was the one known under the name of Priestman, which was improved to somewhat its present form in 1877. The next was known as the Kingston Grab, introduced by Messrs. Rose, Downs, & Thompson as an improvement on the Priestman type, enabling a greater opening tension being applied by the chain in case of fouling. All the above excavators were on the double-chain system of suspension and handling, and necessitated special cranes for their use. The first single chain grab was Wild's Grab, introduced about 1883; and this marks the first step towards the extended use of grabs for mechanical handling as distinguished from dredging or excavating; as, when worked by a single chain, grabs can be attached to any ordinary crane and used wherever such cranes are available.

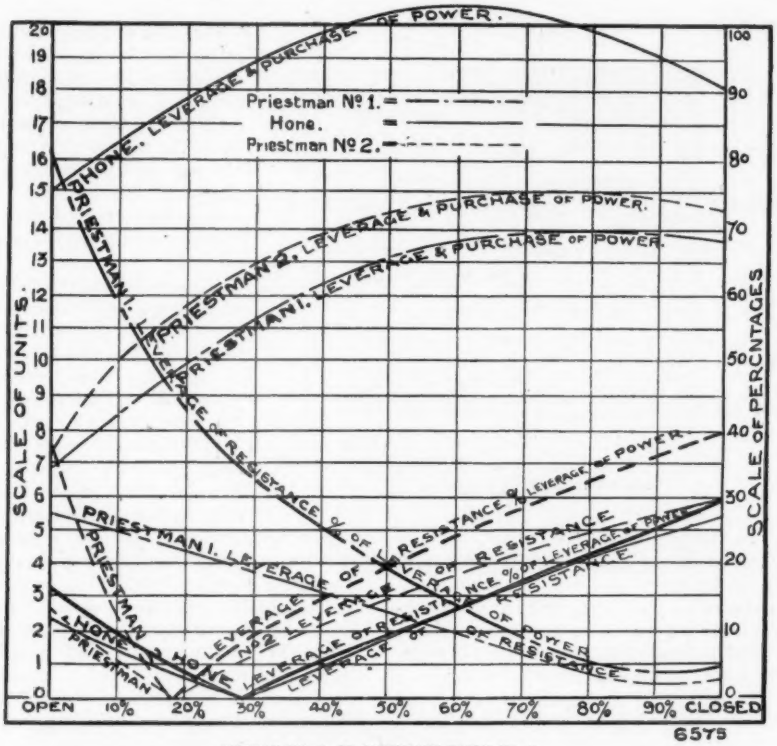

Priestman No 1. =
Hone. =
Priestman No 2. =
HONE. LEVERAGE & PURCHASE OF POWER.
PRIESTMAN 2. LEVERAGE & PURCHASE OF POWER.
PRIESTMAN 1. LEVERAGE & PURCHASE OF POWER.
PRIESTMAN 1. LEVERAGE OF RESISTANCE
PRIESTMAN 1. LEVERAGE OF RESISTANCE % OF LEVERAGE OF POWER.
PRIESTMAN 2. LEVERAGE OF RESISTANCE % OF LEVERAGE OF POWER.
HONE. LEVERAGE OF RESISTANCE % OF LEVERAGE OF POWER.
SCALE OF UNITS.
SCALE OF PERCNTAGES
OPEN 10% 20% 30% 40% 50% 60% 70% 80% 90% CLOSED
6575

DIAGRAM NO. 3, TO ACCOMPANY TABLE NO. 1.

TABLE I.

Position of Buckets.	Table of Moments about Fulcrum, Leverage, and Percentages.											
	Priestman Type 1.				Hone.				Priestman Type 2.			
% of closed.	Leverage of Resistance.	Leverage of Power and Purchase.	Total Leverage of Power.	Leverage of Resistance % of Power.	Leverage of Resistance.	Leverage of Power and Purchase.	Total Leverage of Power.	Leverage of Resistance % of Power.	Leverage of Resistance.	Leverage of Power and Purchase.	Total Leverage of Power.	Leverage of Resistance % of Power.
Open	5·50	2·72 × 2·5	6·80	80·88	2·40	3·75 × 4	15·00	16·00	2·72	2·90 × 2·5	7·25	37·51
10 %	4·92	3·37 × 2·5	8·42	58·43	1·55	4·10 × 4	16·40	9·45	1·22	4·0 × 2·5	10·00	12·20
20 %	4·30	4·08 × 2·5	10·20	42·15	0·75	4·45 × 4	17·80	4·20	0·20	4·7 × 2·5	11·75	1·70
30 %	3·72	4·56 × 2·5	11·375	32·70	0·12	4·75 × 4	19·00	0 625	1 20	5·18 × 2·5	12·95	9·27
40 %	3·10	4·90 × 2·5	12·25	25·30	1·00	4·90 × 4	19·60	5·10	2·10	5·5 × 2·5	13·75	15·27
50 %	2·50	5·23 × 2·5	13·075	19·12	1·75	5·05 × 4	20·20	8·65	2·83	5·72 × 2·5	14·30	19·86
60 %	1·90	5·42 × 2·5	13·575	14·02	2·55	5·10 × 4	40·40	12·75	3·46	5·90 × 2·5	14·75	23·46
70 %	1·30	5·55 × 2·5	13·875	9·36	3·40	5·05 × 4	20·20	16·75	4·22	6·0 × 2·5	15·00	28·13
80 %	0·72	5·60 × 2·5	14·00	5·14	4·10	4·95 × 4	19·80	20·70	4·82	5·93 × 2·5	14·95	32 24
90 %	0·58	5·60 × 2·5	14·00	4·14	4·75	4·80 × 4	19·20	24·725	5·32	5·92 × 2·5	14·80	35·94
Closed	0·52	5·45 × 2·5	13·625	3·82	5·40	4·55 × 4	18·20	29·675	5·80	5·80 × 2·5	14·50	40·00

NOTE.—In Type No. 1 the leverage of the resistance constantly decreases; but in both the Hone and Type No. 2 it first decreases down to 0 at the respective percentages of 28·80 and 18·80, and then increases to over double the initial leverage.

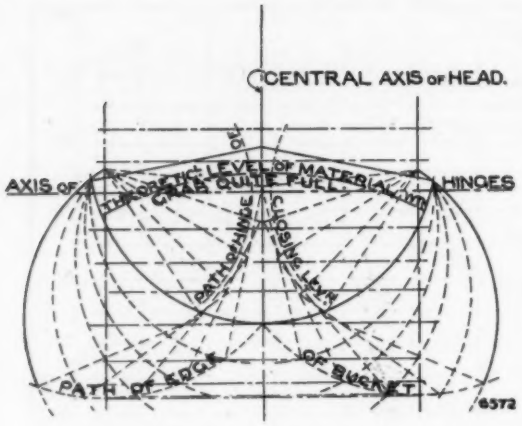


DIAGRAM NO. 4.—HONE GRAB, SHOWING MOTION DURING CLOSURE ABOUT BUCKET HINGES.

The second step is marked by the invention of the Hone Grab in 1894, and this invention may be said to have inaugurated a new epoch altogether in grab construction; as, by its means, the way was opened to the application generally of grabs to mechanical *chemical handling* with which the present paper is especially concerned as distinguished from the operations of excavating or dredging. We will now proceed to examine more in detail the more prominent types of grab in use in Great Britain at the present day, and give some details of their construction, their use and advantages, or the contrary.

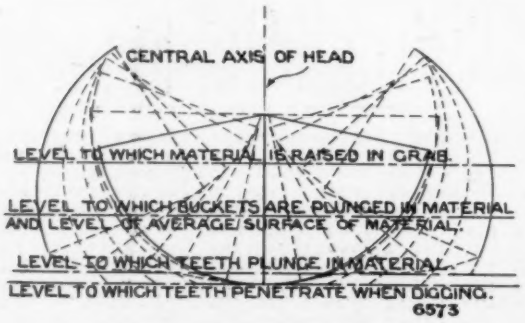
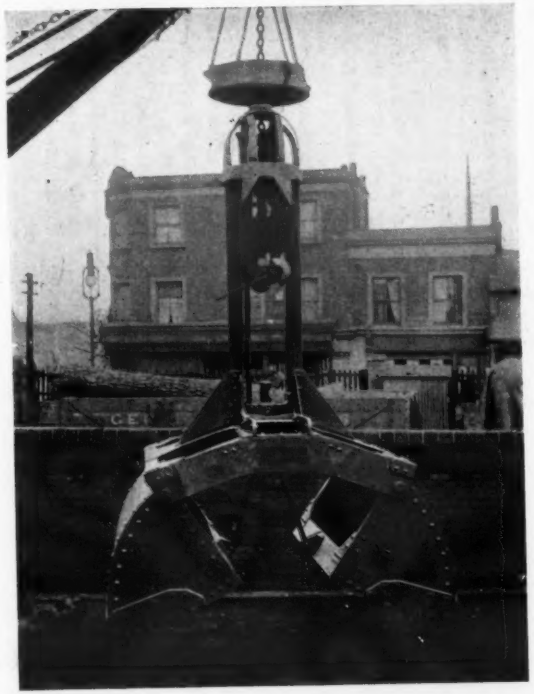

CENTRAL AXIS OF HEAD
LEVEL TO WHICH MATERIAL IS RAISED IN GRAB
LEVEL TO WHICH BUCKETS ARE PLUNGED IN MATERIAL AND LEVEL OF AVERAGE SURFACE OF MATERIAL
LEVEL TO WHICH TEETH PLUNGE IN MATERIAL
LEVEL TO WHICH TEETH PENETRATE WHEN DIGGING.
6573

DIAGRAM NO. 5.—HONE GRAB, SHOWING MOTION DURING CLOSURE ABOUT MATERIAL HANDLED.

All the ordinary forms of grabs now in use have been evolved from the centrally divided hemi-cylindrical hinged skip with square ends, while the special circular grabs for well sinking and cognate purposes have been in a similar way evolved from the cylindrical skip with hinged bottom.

The earliest form of British grab, as already stated, is that known as the Priestman Grab (Type No. 1), which has been in use for some thirty-five years, and was for such a long time without any rival. The best testimonial to the serviceable qualities of this grab lies in the fact that it is still manufactured practically unchanged, and still finds a fairly extensive market. The Priestman No. 1 type is simply a hemi-cylindrical skip divided longitudinally into two equal buckets each approximately a quadrant of a circle in end elevation and a quarter of a cylinder of similar length in capacity. The hinges of these buckets are placed as close to the axis of the cylinder as structural conditions admit, so that in opening and closing the edges of the blades describe approximately circular paths about that axis as centre—for this reason, the extreme width when open is approximately the same as the width over all when closed (see Diagrams 1 and 2). The grab is completed by a fixed vertical frame or handle and two horizontal axles; the lower one fixed, and the upper one movable along slots in the vertical frame, and provided with four short hinged links connecting it to the outer edges of the hinged skip. The lower axle is provided with one central and two side drums of suitable diameter (2½ and 3 to 1 in. diameter), to afford the requisite purchase for working the grab by double suspension. To the

FOUR-BLADED EXCAVATING GRAB, HONE TYPE.



TOOTH GRAB, HONE TYPE.

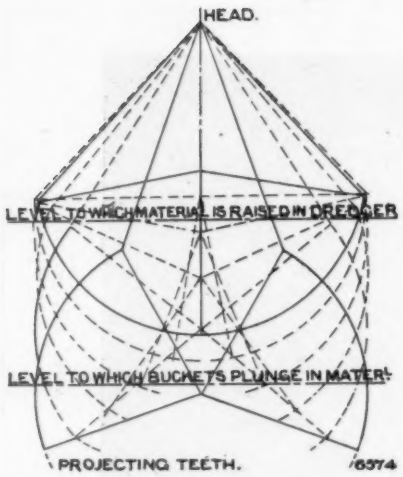


DIAGRAM NO. 6.—PRIESTMAN DREDGER (TYPE NO. 2), SHOWING MOTION DURING CLOSURE ABOUT HEAD.

major drum one end of the crane-chain is attached, and to the minor drums the two short chains are fastened, connecting with the upper axle to which the other end of the crane-chain is in its turn attached. The opening and closing of the grab is

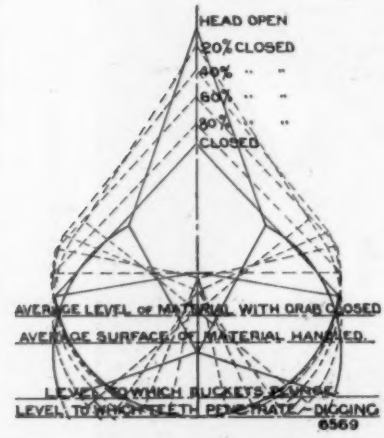


DIAGRAM NO. 7.—PRIESTMAN DREDGER (TYPE NO. 2), SHOWING MOTION DURING CLOSURE ABOUT MATERIAL HANDLED.

effected by means of the four short hinged links previously mentioned. The mechanical features of this type of grab will be readily gathered by reference to Diagrams Nos. 1 and 2, while the mechanical advantages involved are shown in Diagram 3.

The proportion to which a grab is filled in working depends, other things being equal, on the depth to which the blades are plunged into the material to be handled or excavated, and this depth depends primarily on the momentum with which the grab is endowed when the blades are plunged.

Penetration into material whose cohesion is high, and the effective depth of the buckets for working purposes, can be considerably increased, however, by the addition of projecting teeth or tines of various shapes which interlock when the blades are closed. The plain-edged blades are rarely used save for handling thoroughly loose, non-adhering material, such as dry small coal, grain, and powdered materials of various kinds.

Unless the material handled or excavated is very loosely aggregated or soft, the weight of the grab is generally insufficient to cause the grab to sink beyond the level to which the blades have penetrated, when these have reached a position where the tangent to their outer edge or teeth is inclined at an angle of less than 45 degs. to the horizontal; the combined effect of weight and motion in the grab when the edge of the blades is inclined at an angle of less than 45 degs. being, as a rule, insufficient to overcome the resistance to penetration offered by the material. In other words, at this limiting angle the frictional resistance offered by the particles of the material to translation in a horizontal plane tends to become less than the resistance to compression in a vertical plane, and as the blades in closing necessarily follow the path of least resistance, and this lies approximately in the plane uniting their edges from this position onward, the motion of the blades is in a horizontal direction instead of the inclined direction previously followed. Diagrams 1, 2, 4, 5, 6 and 7 illustrate the character of the motion in the three types of grab with which this article is concerned. The total

TABLE II., EFFORTS ON CHAIN DEVELOPED DURING CLOSING, % OF WEIGHT HANDLED TAKEN AS UNITY.

Position of buckets.	Actual effort on chain, % of weight handled.	Reduplication when mechanical leverage during closure is allowed for.	Reduplication when leverage and purchase are both allowed for.
(1)	(2)	(3)	(4)
open	0·00	0·00	0·00
10 % closed	0·286	0·757	3·028
20 % ,,	0·384	2·277	9·108
28·8 % ,,	0·426	∞	∞ *
30 % ,,	0·432	17·136	68·544
40 % ,,	0·476	2·332	9·328
50 % ,,	0·520	1·500	6·000
60 % ,,	0·568	1·136	4·564
70 % ,,	0·605	0·898	3·594
80 % ,,	0·667	0·799	3·196
90 % ,,	0·735	0·742	2·908
closed	1·000	0·842	3·268

* The effort at this point is never actually ∞, as the momentum of the machine carries the buckets past the dead point, and the actual effort is probably what is shown in col. 2.

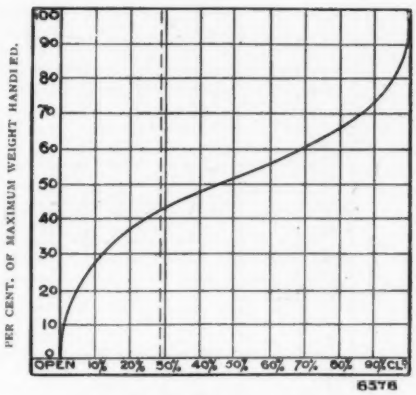


DIAGRAM NO. 8.—HONE GRAB: ACTUAL EFFORT ON CHAIN DEVELOPED DURING CLOSURE, PER CENT. WEIGHT HANDLED (BUCKETS 70 PER CENT. FULL). TO ACCOMPANY TABLE NO. 2.

resistance offered by the material handled, or excavated to the motion of the grab is contributed by the following constituents: *a*, cohesion between the particles of the material opposing readjustment of their relative position; *b*, friction between the particles subjected to readjustment of position; *c*, friction between the material and the blades; *d*, weight of the material readjusted.

Both from the point of view of low first cost and general handiness, small power cranes have down to very recent times been considered the most desirable, and the medium and large sizes have been considered as more or less exceptional. The most usual size of crane throughout the ports of Europe has hitherto been the 1,500-kg. ($1\frac{1}{2}$-ton) type, originated some fifty years ago in France. This type was designed to supplement and not replace human labour, and these cranes were only intended to enable the dock labourers to deal with packages incapable of subdivision, whose weight or size just exceeded

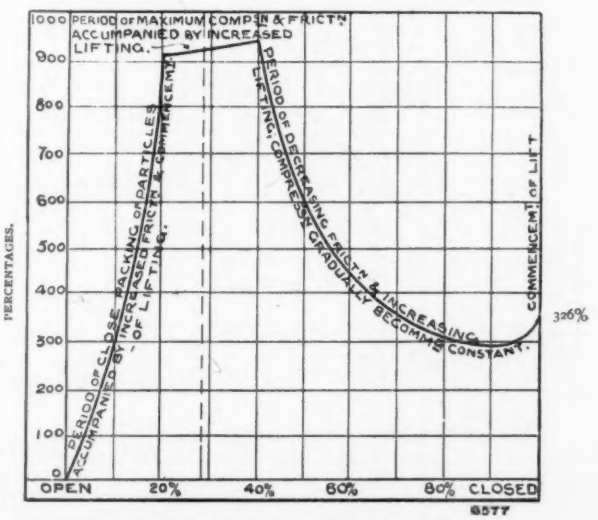


DIAGRAM NO. 8A.—HONE GRAB. TO ACCOMPANY TABLE NO. 2.

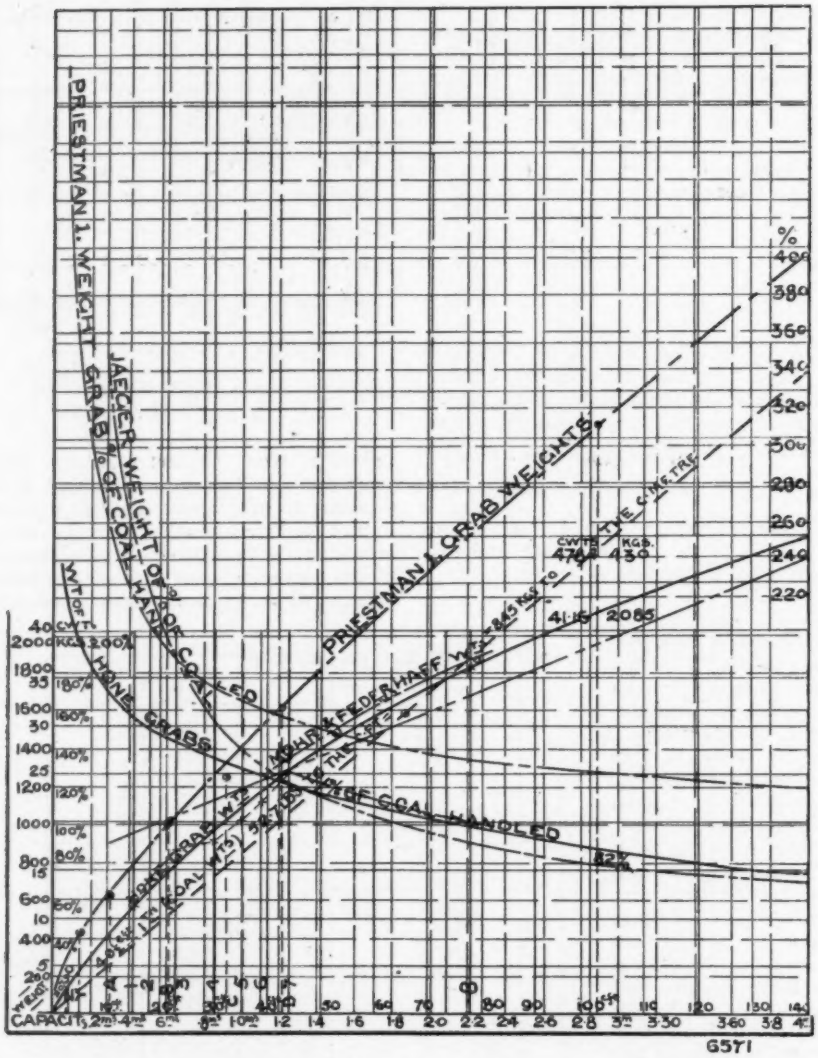


DIAGRAM NO. 9.—SHOWING WEIGHTS AND CAPACITIES OF VARIOUS TYPES OF GRAB AND THEIR RELATIVE PERCENTAGES TO COAL HANDLED. TO ACCOMPANY TABLES NOS. 3 AND 4.

TABLE III.

HONE'S GRABS (Single Chain).

Catalogue size.	Maker's Particulars.				Derived Particulars.							Remarks.
	Maximum capacity. Cubic ft.	Weight of grab. Tons.	Weight of coal assumed at 40 cubic ft. to the ton, or 32·7 lbs. to the cubic ft. Tons.	Total weight handled. Tons.	Rate of discharge in tons of coal per hour with ordinary steam crane at about 40 ft. lift. Tons.	Rate of discharge in cubic ft. per hour. Cubic feet.	Average number of lifts per hour.	Time in seconds. Total per lift.	Closing grab.	Discharging grab.	Grab in motion.	Distance travelled while in motion.	Average rate of travel. Feet per second.	Effort developed by crane while hoisting loaded grab. Foot-tons.	Effort developed by crane while hoisting loaded grab. H.P. seconds.	
1	15	0·55	0·3529	0·9029	20	850·0	56·67	63·52	1·76	0·88	60·92	Crane with jib of 18 ft. radius. Horizontal travel 113·0973 Vertical ditto 80· Total ... 193·0973	3·170	2·862	11·659	No. 1.—The working capacities of the grabs under favourable conditions are stated to be :— For coal ... 90% of maximum For chalk and iron ore 65 to 70% ,, For broken stone (Macadam) 75% ,, The effort exercised by the crane while the grab is closing is shown on Diagram No. 8.
2	18	0·70	0·4235	1·1235	24	1020·0	56·67	63·52	2·12	1·06	60·34		3·200	3·595	14·645	
3	23	0·85	0·5411	1·3911	31	1317·5	57·29	62·84	2·70	1·35	58·79		3·300	4·601	18·744	
4	30	0·90	0·7058	1·6058	37	1558·0	52·42	68·67	3·53	1·76	63·38		3·046	4·892	19·923	
5	35	1·00	0·8234	1·8234	43	1827·5	52·22	68·94	4·12	2·06	62·76		3·077	5·610	22·905	
6	39	1·10	0·9216	2·0216	45	1912·5	48·83	73·73	4·61	2·30	66·82		2·890	5·842	23·796	
7	44	1·25	1·0398	2·2898	50	2125·0	48·09	74·87	5·20	2·60	67·07		2·879	6·592	26·915	
8	78	1·80	1·8351	3·6351	72	3060·0	39·24	91·75	9·17	4·58	78·00		2·475	8·999	36·656	

The weight of the chain or wire rope by which the grab is handled is omitted in the above scale of weights, but as the grabs under favourable conditions handle 10% less coal than their maximum capacity the total weights and total efforts developed will not be exceeded. The latter are also independent of the effort expended on moving the crane itself.

TABLE IV. PRIESTMAN DREDGERS, Type No. 1 (Double Chain).

Maker's Particulars.							Derived Particulars.									Remarks.
Catalogue size.	Maximum capacity. Cubic ft.	Weight of grab. Tons.	Weight of coal assumed at 47 cubic ft. to the ton, or 47·68 lbs. to the cubic ft. Tons.	Total weight handled. Tons.	Rate of discharge = approximate capabilities of machines per day of 10 hours. Per hour. Tons.	Rate of discharge in cubic ft. per hour. Cubic feet.	Average number of lifts per hour.	Time in seconds. Total per lift.	Closing grab.	Discharging grab.	Grab in motion.	Average rate of travel. Feet per second.	Average rate of travel. Feet per second.	Effort developed by crane while hoisting loaded grab. Foot-tons per second.	H.P.-seconds.	
Z	3·225	·225	0·0686	·2936	5·5	258·0	80·0	45·0	0·36	0·18	44·46	A 50·25 B 40 C 56·55 D 40	1·749	0·2567	1·0458	Note the radius of jib for Dredger— "Z" is 12 ft. 75·39 circumference. Y ,, 14 ft. 87·96 ,, A ,, 16 ft. 100·50 ,, B C and D is 18 ft. 113·10 ,, It will be noted that the disadvantage of the double chain handling in respect to speed is made up largely by the diminished effort required to be developed during hoisting, which is about ½ of that in single-chain grabs.
Y	5·375	·425	0·1144	·5394	10	469·8	87·4	41·20	0·80	0·40	40·00		2·094	0·5647	2·3000	
A	10·75	·6125	0·2287	·8412	20	939·6	87·4	41·20	1·60	0·80	38·80		2·326	0·9781	3·975	
B	21·50	1·000	0·4574	1·4574	40	1879·1	87·4	41·20	3·20	1·60	36·40		2·652	1·9235	7·872	
C	32·25	1·2375	0·6862	1·9237	55	2580·0	80 0	45 00	4·80	2·40	38·80		2·488	2·3930	9·748	
D	43·00	1·600	0·9149	2·5149	70	3418·0	76·49	47·05	6·37	3·13	37·55		2·571	3·2329	13·168	

Type	Z	Y	A	B	C	D
Horizontal	37·7	43·76	50·25	40	56·55	40
Vertical	40	40	40	—	—	—
Total	77·7	83·76	90·25	96·55		

NOTE.—The average lift allowed for is stated to be 20 ft., and the swing of the crane-jib seems to be ¼ of circumference; the speed of swing of crane would probably be over 3 ft. per second, and that of the lift about ½ that amount; but in calculating the maximum effort during lift the average rate of travel is taken, so that the results are higher than the actual effort expended, but are halved for double chain.

the limits of directly applied human strength—the general practice and intention being to subdivide down to that limit as a rule, and only handle beyond that limit as an exception.

The use of skips attached to cranes for certain special kinds of handling did not necessarily involve an increase of power beyond that established by the type in question, as the volume of material to be handled could conveniently remain small, and the proportional weight of the skip was also small. Thus a 1½-ton crane was in general amply sufficient to afford the necessary margin of power for dealing with all the handling required under the conditions then obtaining.

But the transition from a passive to an active engine, *i.e.*, from the skip to the grab, attached to cranes, involved a relatively enormous increase in the proportion of the dead weight contributed by the handling-engine, and the working margin of the crane power became insufficient or the volume handled had to be diminished.

HONE-TYPE HIGH-CAPACITY GRAB.

The alteration of the current type of crane equipment has presented very serious obstacles to the general adoption of mechanical handling, and has undoubtedly prolonged the epoch of manual handling far beyond the limits imposed by the conditions of modern commerce, to the obvious detriment of the interests of the vast majority of continental and home ports. This fact contributes one more to the lengthy list of instances belonging strictly to the sphere of human agency, where a type once established has persisted long after its suitability to the conditions of the environment has passed away.

Considerations of limiting weight, imposed by the conditions of crane power above alluded to, clearly indicated the direction in which improvements in the construction of grabs had to be sought. The problem to be solved was how to diminish the weight of the grab without unduly increasing the crane velocities and without decreasing the working capacity of the grab, or, what comes to the same

thing, continue to fill the buckets to an equal extent while sensibly decreasing the penetrating power of the grab into the material handled.

In the result the attempts to successfully solve this problem led, as we have already stated, to the introduction of the first really important innovation in the design of grabs, embodied in the type known as the "Hone Grab" — which marked an epoch in grab making as previously stated — an innovation which has produced such a plentiful crop of imitations, both in America and Germany. This consisted in separating the hinges of the buckets to a relatively considerable extent, as compared with the original type, and placing them on a special horizontal frame added for this purpose. This separation of the bucket hinges by a comparatively large interval permits of the blades opening wider than the closed dimensions of the grab, and of the collection of the material to be handled over a much larger area than was previously the case, resulting in a commensurate diminution in the depth to which the blades have to be plunged to obtain full buckets. A reference to Diagrams 2, 5, and 7 will make this clear, and the comparative results for the three types of grab with buckets of constant capacity are entered on table No. 1.

A further advantage of this ability to open the blades in excess of the closed dimensions lies in the improved ease of working due to the progressively increasing clearance behind the buckets as closing is effected, which prevents adherence between the grab and the undisturbed material surrounding it. This automatic clearance is obviously of considerable importance in dealing with substances in a wet and more or less sticky condition, which is unavoidable with material handled or excavated below water-level, as well as in handling moist material of many kinds above that level. The amount of this clearance varies directly as the distance of the hinges of the blades from the axis of the cylinder of which the closed buckets form a portion, and vanishes when the hinges coincide with that axis.

The leading mechanical features of the Hone grab, which are of general interest, may be summarised as follows:—

The introduction of (1) a sheave-block moving between the four angles of the frame-work of the grab-head, which enables any required purchase to be obtained; and (2) a cross-head similarly moving, to which the closing links or connecting-rods are attached, and with which the sheave-block can engage by the intermediary of a locking pin and releasing lever; (3) a discharging ring which effects the automatic release of the lever at any desired height, and the disengaging of the locking pin attached to the cross-head, so that the weight itself of the material handled operates the opening of the buckets and the discharge of their contents; (4) a vertical dash-pot whose piston is connected with the cross-head and serves to check the latter's descent when disconnected from the sheave-block and prevents the discharge being too sudden. When the grab is being lowered on to the material to be handled, the sheave-block is at the top of the frame and the cross-head at the bottom. When the material is reached, and the grab at rest, the sheave-block descends by its own weight and engages with the locking pin, the lever automatically effecting the locking. On the chain being reset in the sheave-block with the cross-head are pulled up towards the top of the frame, and the closing of the buckets is effected by the connections between the cross-head and the buckets. The grab itself does not lift till the sheave-block has reached the top of its course, carrying the cross-head with it, and the buckets are completely closed. The grab can then be raised till the long end of the releasing lever has passed through and above the releasing ring, *i.e.* to the desired height at which the free swing of the crane can be operated. When the grab is brought over the spot where the discharge is to be effected, the lowering commences, and the long end of the releasing lever is tripped by the discharging ring or by hand, and the contents emptied out. The cycle of loading is then recommenced and so on.

In grab work under water with grabs where the clearance is very slight it has often been found impossible with the

ordinary crane to lift the grab from the bottom, as the adhesion has been so great as to induce a strain on the chain attached to the crane beyond the capacity of the latter, and the grab has had in some cases even to be abandoned at the bottom. Where the clearance is considerable this untoward difficulty is very unlikely to occur, as the edges of the blades are alone in contact with the material dredged at the moment of closing, the backs of the buckets being practically clear.

A further improvement embodied in the Hone grab and its derivatives for accelerated crane working was that this grab, unlike the original Priestman dredger, could be worked with single chain or rope suspension. This feature made it readily adaptable to all the ordinary types of cranes, which are designed more usually for single than double chain working, and the single chain grab for general purposes has practically driven the double chain grab off the field. Double suspension has held its own, however, where grabs are worked in connection with transporters, as single suspension is generally impracticable for lack of sufficient head room, but it has also militated against their use in this connection, as it has reduced their speed of working to a very undesirable extent.

Chain suspension, it should be observed, has, with transporters, to be replaced by wire-rope suspension, and the combined effect of the variation in the diameter of the sheaves inseparable from the use of wire-rope, and the inherent deficient flexibility in the wire-rope itself when compared with a chain, has also tended to reduce the working speed of grabs with transporters to a further undesirable extent.

Both the Priestman No. 1 Type and the Hone grab possess the valuable characteristic of having their working parts placed so that they cannot be fouled by the material dealt with, but they also, as a consequence, possess a characteristic in common which, under certain conditions of work where the space is confined vertically (say between decks, or in holds with small hatches, and extending long distances away from those hatches), is decidedly a drawback, and that feature is a lofty head or top frame.

The central-hinged double suspension grab (Priestman No. 1 Type) has held its own, as was stated at the commencement of this paper, largely because, firstly, it was the first in the field, and because, secondly, it was fairly well adapted to the special conditions of the dredging work for which it was introduced (in this work it is always desirable to have an abundant reserve of power available, and double suspension united with slow speed of working ensured this), and thirdly, because its non-adaptability to more general conditions did not encourage imitations, and finally, because its improvement beyond its initial degree of excellence was practically recognised to be an impossibility. The case of the haunch-hinged single suspension grab (Hone type) has been wholly different; here the imitators have been many and the modifications not a few. In a single suspension grab the opening of the grab to release the material taken up and handled has to be effected independently of the crane chain to which the grab is attached (which, however, still has to effect the closure), and a system of releasing levers and catches, or locking-pins, had to be superadded of a more or less complicated character. This has afforded occasion for the exercise of much ingenuity on the part of inventors and led to a number of special patents — from which have originated the majority of the haunch-hinged single-chain grabs which are now competitors of the Hone grab. These, independently of the special system of release characteristic of the individual grab, can be divided into two general classes. First, those in which the working parts do not come in contact with the material handled, *e.g.*, Hone (England), Brown (U.S.A.), Bleichert (Germany), etc., and, second, those in which the working parts do come in contact with the material handled, *e.g.*, Hunt (U.S.A.), Jeger (Germany), and, finally, a class by itself, Priestman Type No. 2 (England).

It should be noted that all these grabs are capable of being worked on a double chain instead of a single one, if required, but at a commensurately reduced rate of working.

In Class No. 2 above, the penetration is necessarily more limited than in Class No. 1, as an extra obstacle is provided to penetration by the working parts coming in contact with the material handled when the grab is open. All the grabs of both classes could be called more or less headless, save the Hone type, as they have no special projecting framework forming a handle or head.

The Priestman Type No. 2 dredger was introduced to meet the demand for single chain grabs, which had grown so largely with modern conditions of mechanical handling, as apart from the excavating of materials on a large scale. Diagrams No. 6 and 7 show the mechanical features of this type of grab, which are interesting, as they represent an attempt to amalgamate some of the features of both the central hinged and haunch-hinged types. The attachment of the buckets at the centre is preserved so far as to keep them together throughout the whole cycle of motion, but they work on haunch hinges, whose distance apart varies from instant to instant throughout the motion. It will be seen (by reference to Diagrams 6 and 7) that the drawback of insufficient clearance when dealing with materials in which the grab is liable to stick has accompanied the feature of the central attachment copied from the earlier Priestman No. 1 Type, and that of diminished penetration after plunging has accompanied the hinging at the haunches, while the relative amount of requisite plunging, *i.e.*, the initial momentum, to produce full buckets is higher than in either of the two types of grab which have been examined in detail.

The mechanical advantages of the three types, or the leverage conferred on the power applied, as compared with the resistance encountered in each of the three types, are given in Diagram 3 and Table 1 in the form of curves and figures, which will explain themselves.

From these the amount of the actual resistance overcome in closing the Hone type of grabs when handling dry gas coal has been calculated by means of the data entered in Table 2 and Diagrams 8 and 8A, where the actual pull on the chain working the grabs, as determined by experiment at various instants of closing, is entered in the form of a percentage curve of the total weight (grab and contents) handled. These diagrams show how important is the effect of the mechanical advantages embodied in the design of the grabs themselves in diminishing the strain on the chains or ropes with which the grabs are worked.

Diagram No. 9 shows the relative advantages of several well-known types of grab in England and Germany in respect of weight for coal handling, the standard coal weight with which they are compared being an average coal running 40½ cub. ft. to the ton; the Admiralty allowance is 48 cub. ft. to the ton, the difference being in the length of time. The coal in the latter case is presumably stacked before stowing in the bunkers.

Two tables, Nos. 3 and 4, have been computed and added from data given in the publications connected with the Priestman and Hone grabs, which give an idea of the speed with which the handling of coal at certain lifts is effected. The efforts developed by the crane in the shape of pull on the chain while hoisting have been added in foot-tons and h.p.-seconds, from which an idea of the work done can be arrived at.

The author has been unable to add a similar table for the Priestman dredger, Type 2, as the data for these grabs he was unable to obtain. The advantages of the single chain as compared with the double chain grabs in respect to rapidity of handling are clearly apparent from the tables, and do not require to be further pointed out. No actual comparison has been drawn between the performance of the Hone grabs and the Priestman Type 1 dredgers, as this would be treading on obviously delicate ground.

The author has not attempted to go into the question of excavating and dredging as distinguished from handling, as this would, he considers, have taken him far beyond the limits of a magazine article. Neither will he attempt to give other than the most general idea of the economical results obtained by grab handling as compared with handling ordinary skips filled by hand labour with shovels. He has a considerable amount of both English and foreign data on the subject, but the conditions

are so diverse that he feels it practically impossible to generalise with any approach to accuracy. All that can safely be stated is, that the experience of some of the largest gasworks in the United Kingdom has shown that by grab handling the cost can be reduced to from $\frac{1}{3}$ to $\frac{1}{4}$ of the sums previously expended in handling coal with the same cranes and lifts worked with skips filled by hand—that is, from, say, 4½*d.* a ton to 1½*d.* or even 1¼*d.* per ton of coal handled. Where the handling comprises considerably over 1,000 tons a day the saving even at this rate of economy represents a very large figure per annum. The same has been found to be the case in all classes of handling to which grabs have been applied.

Under modern conditions of production it is not too much to say that no manufacturer or producer can afford to do his *handling by hand*, and that if it is done by hand either the amount is insignificant or the concern which continues the practice is on the broad straight road to ruin.

THE TELEGRAPHIC TRANSMISSION OF PHOTOGRAPHS.

(Communicated.)

MANY more or less successful attempts have been made in recent years to devise a method of reproducing photographs, drawings, and handwriting at a distance by means of electricity. The selenium cell, the action of light upon which diminishes or increases its resisting properties, afforded a ready means of transmitting fluctuations in the intensity of a source of illumination, and of converting these differences of light intensity into the oscillations of an electric current.

If, for example, a beam of light and a selenium cell be simultaneously passed over the opposite surfaces of a photographic negative, varying degrees of opacity of the plate will set up corresponding oscillations of the current in the circuit of the cell. This is the common feature of all the transmitting devices hitherto suggested.

The current oscillations are made to act on a receiving apparatus which will convert them into fluctuations of light intensity. The design of the receiving apparatus has, however, so far been the weak point in all these systems, because the electric currents transmitted are so very feeble. Furthermore, the synchronous working of the transmitting and receiving apparatus has been a source of difficulty, and but imperfectly secured in previous forms of apparatus. This does not, however, appear to be the case with the teleoptical system of Prof. Arthur Korn, of Munich, whose success is due principally to the employment of a

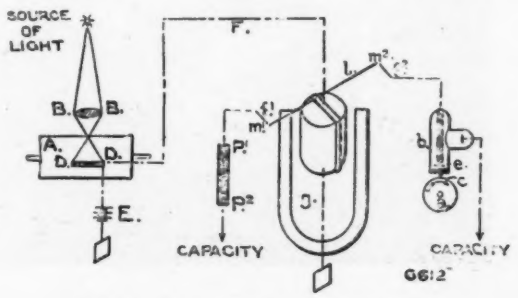


FIG. 1.—DIAGRAM SHOWING THE ARRANGEMENT OF PROF. KORN'S TELEOPTICAL SYSTEM.

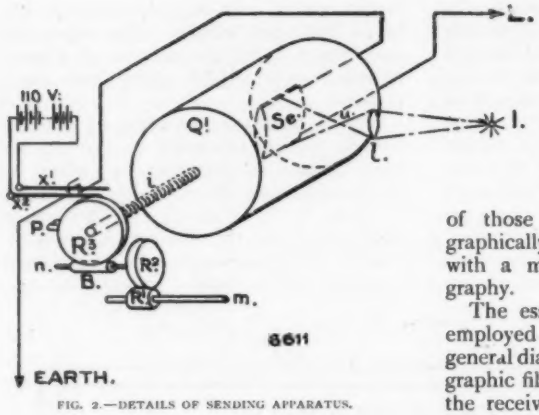


FIG. 2.—DETAILS OF SENDING APPARATUS.

vacuum tube as an adjustable source of light at the receiving station.

While engaged in investigating the radiations given off by the electrodes of a vacuum tube exhausted to a pressure ranging between 0.2 and 2 mm, Prof. Korn noticed, as Hertzian vibrations were applied to the electrode, the extreme sensitiveness with which these radiations would react on small alterations in the circuit. The sensitiveness suggested a possible utilisation of those radiations which were photographically most efficient, in connection with a method of electrical telephotography.

The essential feature of the apparatus employed may be gathered from the general diagram, Fig. 1. A sensitive photographic film wound round the cylinder of the receiver rotates in front of a small opening, *c*, (0·25 mm. × 0·25 mm.) in a vacuum tube, *b*, the surface of which is coated with black paper and tinfoil. By means of high frequency currents, luminous radiations are produced inside the tube, which, after passing through the small

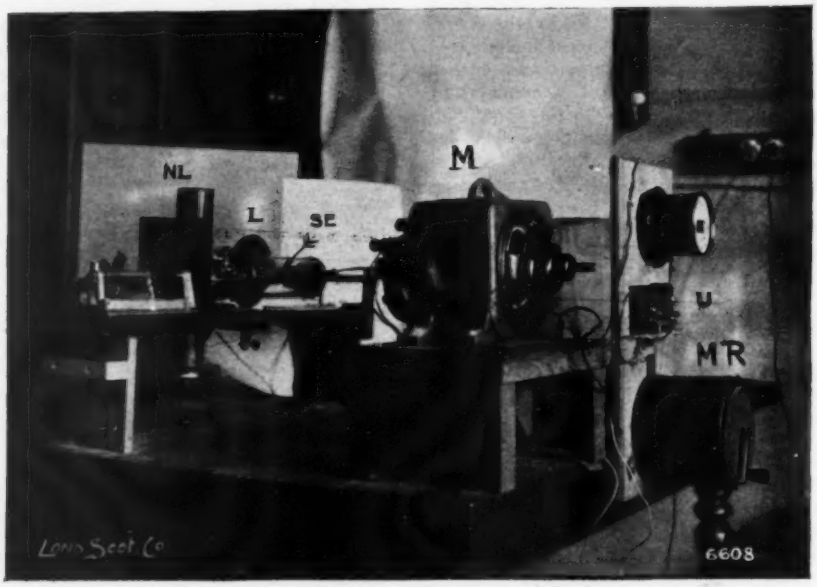


FIG. 2A.—VIEW OF THE SENDING APPARATUS.

FB Frequency Indicator. *L* Lens. *M* Elecromotor. *MR* Motor Regulator.
NL Nernst Lamp. *SE* Selenium Cell. *U* Switch.

FIG. 3A.—VIEW OF THE RECEIVING APPARATUS.

G Galvanometer. *WW* Resistances. *R* Regulating Resistance. *M* Electromotor. *S & H* Relay. *RH* Geissler Tube.

opening, act on the sensitive film in a spiral line exactly like the stylus of a phonograph. The roller is moved synchronously with the glass cylinder of the sending apparatus *A*, on which is wound a film bearing the photograph to be transmitted, on which is directed a concentrated beam of light *B*, *C*, *D*, from a Nernst lamp. The beam of light penetrates the film and strikes a selenium cell *D*, placed inside the cylinder. According to the different shades in the photograph to be transmitted, the selenium cell will receive more or less light, by which its resistance is raised or lowered; while an electric current from an accumulator which is connected up in series with the cell and the conductor *F*, will undergo corresponding variations of intensity, thereby regulating the intensity of the light radiations of the receiving tube. The light from the tube being regulated by the current according to the depth of shade of the film at the sending station, a corresponding image will be

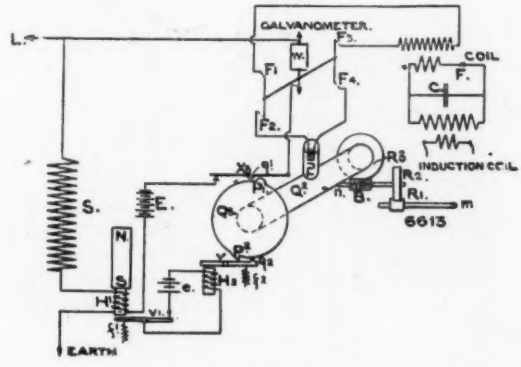


FIG. 3.—DETAILS OF THE RECEIVING APPARATUS.

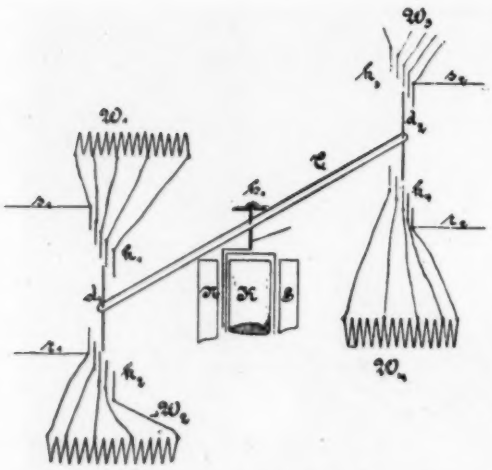


FIG. 4.—RHEOSTAT APPARATUS IN THE TESLA COIL CIRCUIT WHICH IS NOW USED INSTEAD OF THE SPARK GRADUATION.

produced. This is provided for in the ollowing way: The active electrode, e, of the tube being connected to one of the poles P, of the secondary coil of a Tesla apparatus, by inserting fields of sparks formed by the points m_1, m_2 of a galvanometer needle, l, and two fixed points f_1, f_2, the intensity of the radiation given off by the tube will vary according to the distances m_1, f_1 and m_2, f_2 which again vary according to the strength of the current transmitted through the galvanometer g.

Now as to the details of the different parts of the apparatus, a diagrammatic view of the sending apparatus is shown in Fig. 2. The photograph to be transmitted in the shape of a transparent film is wound on the glass cylinder Q_1, which is made to rotate by means of an electromotor and a worm gearing (R_1, R_2, BR_3); one revolution being made in from 20 seconds to $\frac{1}{20}$th of a second, during which the cylinder is displaced by 1 mm. in the direction of its axis which is fitted with the screw i. The dimensions at present used are :—

Diameter of glass cylinder ..	8 cm.
Length of glass cylinder ...	20 cm.
Length of screw in the axis	15 cm.
Length of the film ...	9 to 12 cm.

From the illuminant J, which is a 64-cp. Nernst lamp, the light passes through the lens to a point u, of the film, and, after penetrating through the glass cylinder, strikes the selenium cell *Se* which is rigidly mounted in the interior of the cylinder.

The details of the receiver are shown in Fig. 3. The roller Q_2, is rotated through the worm gearing R_1, R_2, BR_3, by means of an electromotor. The speed of the latter is so controlled as to be one per cent. greater than that of the transmitting motor, and the roller Q_2, after each rotation, is stopped by means of the lever q_2, until the synchronism signal arrives from the sender. Along the roller Q_2, which is 2 cm. in diameter and 12 cm. in length, a small vacuum tube is made to travel $\frac{1}{4}$ mm. per second in a direction parallel to the tube itself, the beam of light from the tube thus describing a spiral line of small pitch. The varying intensity of the beam

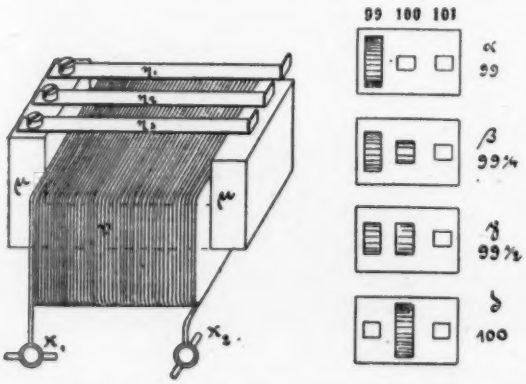


FIG. 5.—HARTMANN-KAMPF FREQUENCY INDICATOR.

of light depends, as before mentioned, on that of the original at the sending end, hence there is reproduced on the sensitive film a duplicate of the original with a reduction in size by 1 : 4.

Instead of the spark graduation above described, the inventor now obtains the variation in the value of the current by means of resistances inserted in the circuit of the Tesla coil (see Fig. 4). The needles d_1, d_2 slide along the four combs, k_1, k_2, k_3, k_4, which are constructed of thin mica and metal plates, $\frac{1}{4}$mm. in thickness, superposed and compressed; the resistances w_1, and w_2, w_3, w_4 being inserted between the various pairs of metal plates. In the figure only five metal plates are shown for each comb, whereas in the actual arrangement used by Prof. Korn, 26 plates are being used, the total length of the comb being about 16mm. Prof. Korn thinks, however, ten metal plates to be quite sufficient. The wires s^1, s_2 connect with the poles of the Tesla coil, and the wires r_1, r_2 with the tube. The co mbs are mounted on india-rubber insulating supports, while the resistances w ar e placed in special boxes.

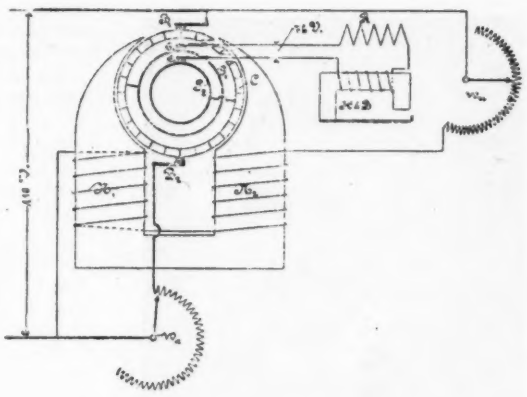


FIG. 6.—DETAILS OF SPEED REGULATOR CONNECTIONS.

The transmission of a photograph of 9 × 16cm. requires just 30 min. with the speed of roller at present used, the limiting factors being the inertia of the selenium in the transmitter and the inertia of the galvanometer in the receiver.

In order to compensate for possible errors due to the inertia of the selenium, the space left free on the sender roller is used for inserting a uniformly illuminated film-strip serving to check the working of the selenium. If any error be noted, the sensitiveness of the galvanometer has to be altered accordingly.

Special care has been bestowed by Prof. Korn on the design of the apparatus for securing the synchronous rotation of the rollers. As it is quite impossible to obtain absolute synchronism, the unavoidable small errors occurring have to be compensated for at reasonable intervals, so as to prevent them from becoming appreciable. Continuous current $\frac{1}{4}$-h.p. shunt-wound motors are used for obtaining a uniform rotation of the cylinders, current being supplied from accumulators. For measuring and adjusting the proper speed,

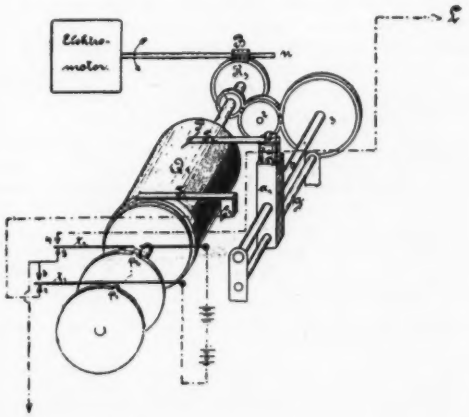


FIG. 7.—SENDING DEVICE FOR TRANSMITTING HANDWRITING.

FIG. 8.—A TRANSMITTED PHOTOGRAPH.

one of the motors is fitted with collector rings for alternating-current supply, the latter being led on to a Hartmann-Kempf frequency indicator. This (Fig. 5) is based on the principle that, out of a series of tuned springs, the one whose period is in resonance with the period of the alternating current will be caused to vibrate by an electromagnet excited with the current. In Fig. 5, η_1, η_2, η_3 represent three such springs having the period of 99, 100 and 101 respectively, K_1 and K_2 being the terminals connecting to the alternate current that traverses the coil ν round the iron core μ consisting of transformer plates. In α, β, γ, δ, a front view of the spring in the actuated state is shown for the period 99, 99¼, 99½, and 100 respectively. In Fig. 6 the connections for the speed regulator are shown diagrammatically. B_1 B^2 are the continuous-current brushes, C the commutator, S_1 S^2 the collecting rings, b_1 b_2 the brushes intended for collecting alternating current, R a shunt resistance for the frequency indicator H and B, w_a the starting resistance of the motor, and w_n the regulating resistance in the shunt.

In order to simplify the necessary corrections for the errors in synchronism, the speeds of the motors at the two stations are arranged to differ from one another. At the sending station the frequency adopted is 99½, that at the receiving station being 100½. Any regulation is therefore only necessary in one direction, and after each revolution the more rapidly rotating roller has to be stopped by $(\frac{1}{100} + \epsilon)$ of the time of rotation, where ϵ is the positive or negative relative error of synchronism.

When handwriting or drawings are to be transmitted, a sending device constructed on Bakewell's principle may be used, in which the writing or drawing is made with non-conducting ink on a metal foil. The metal foil (Fig. 7) is wound round the india-rubber cylinder Q, of the same dimensions as the receiving cylinder. The support a_1, along with the spring F_2 and the metal pin P, are made to slide over the metallic surface from which the current is led through a sliding contact into the line wire, the circuit being broken whenever the pin P touches a non-conducting portion of the metal foil.

In the receiving apparatus the galvanometer is replaced by a polarised relay which actuates a high-tension relay connected to the Tesla coil circuit. When the circuit is broken by the sending apparatus, variations in the Tesla coil current are produced which are utilised for forming, on the receiving film, dots which compose the writing or line.

By means of the latest apparatus, 500 words in ordinary handwriting, or from 2,000—2,500 words in shorthand, may be transmitted per hour.

In Fig. 2A we reproduce a photograph of the transmitting, and in Fig. 3A one of the receiving stations.

Prof. Korn has successfully transmitted photographs over the Munich-Nurnberg line, one of which is reproduced in Fig. 8.

BOOK REVIEWS.

Liquid Fuel and its Combustion.—By Wm. H. Booth, etc. (Westminster: Archibald Constable & Co., Ltd., 2, Whitehall Gardens, 1903.) Price 24*s.* net.

The use of liquid fuel has long been an interesting and even alluring subject to engineers, but it was soon apparent that the question of the sources of supply was the dominant factor of the problem. Consequently, it has only been since the development of the Russian and Texan oil-fields that the practical employment of oil fuel has assumed a moderate degree of prominence. Even now, as Mr. Booth points out, the total oil production of the world is not 5 per cent. of its coal production, so that any idea of its entirely displacing coal must be out of the question, unless the yield of oil be increased beyond any present prospects, and even its limited use must be undertaken with caution. For special service—such as that of marine work, that of railways in countries without coal supply, or that of electric light and power stations—the use of oil as fuel for the production of steam possesses several advantages, and both the light petroleums, or oil spirits, and the heavy or "dead" oils are in successful use for internal combustion engines, both of the stationary and of the portable or motor-car varieties. The ease with which it can be handled, stored, transported and applied, with the minimum of labour, and with completeness of effect, give to oil the character of a *beau-ideal* fuel; and Mr. Booth has dealt with the subject in so comprehensive a manner as to make this volume a valuable storehouse of information on the various branches of his subject. In his book of over 400 pages and 150 illustrations, including appendices and index, he has dealt with both theory and practice in a way which leaves little to be desired, and, in fact, the principles enunciated in the first division of the work are, along with chap. xxxii. in Part II. and the tables in Part IV., of equal value in view of the employment of other forms of fuel. Mr. Booth, however, does not deal with internal combustion engines, but confines himself to the application of liquid fuel to evaporation, with a short chapter on its application to metallurgical work.

Part I. deals with theory and principles. It embraces about 100 pages, and contains chapters which treat of the chemical and physical properties of petroleum, the conditions of its use as fuel, and its comparative value with coal; combustion, smoke, calorific, and other units, and the calorific power of fuels; water, its properties and purification; refractory materials used in furnaces, and historical and statistical facts connected with his subject. In Part II. he deals with practice, and devotes about 180 pages to the storage of oil in ships; marine furnace gear; liquid fuel application to locomotives, to stationary and other boilers; the mixed system of coal and oil combustion; Russian, American, and English practice with various systems; air and steam atomisation; compressed air; storage and distribution of liquid fuel; flue gas analysis; calorimetry and draught; various kinds of atomisers; application of oil fuel to metallurgy; oil carriage by rail; and Ringelmann's smoke chart. Part III. contains some useful appendices, giving the rules of Lloyds and various American Boards of Underwriters as to the carrying and burning of liquid fuel, and some reports on oil storage, and on the performance of some installations of oil fuel. Numerous tables, theoretical and practical, form Part IV., and a useful index completes the volume.

The general subject is one which does not offer much scope for original treatment in these days, and Mr. Booth's volume is not put forward with any such claim, except with regard to the nature of the combustion of bituminous fuels, on pp. 97–103. The value of his work consists in the comprehensive view which it gives of the present-day state of the subject and the numerous important facts and principles which it records. The author, however, does but scant justice to Harrison Aydon; for, whatever may have been the prevailing state of ignorance in his day, he was undoubtedly the pioneer of that very system of "atomising" (as it is called) which Mr. Booth

considers as alone fitted for heavy oils. Aydon was, moreover, undoubtedly ahead of others of his day in appreciation of the physics of combustion, and Mr. Booth has apparently omitted to give him due credit for the view of the constitution of liquid fuel which he thus expressed: "Here was a fuel naturally prepared the first stage towards gasification, as to effect the same result artificially 6,000 or more heat units would have to be expended, which heat would become latent and so be lost as useful work. Now these 6,000 heat-units added to 15,000 heat units derived from converting or burning carbon into carbonic acid would give 21,000 heat-units, which the late Professor Rankine stated to be the amount due to gaseous carbon." Even with regard to the dissociation of the steam used in spraying it should not be forgotten that, as was pointed out by the writer of "Fuel and its Applications" (vol. i. of Groves & Thorpe's "Chemical Technology"), "the temperature at which steam is dissociated *in the presence of gaseous carbon* must be less than that which is required with steam and *solid* carbon by at least the equivalent of the quantity of heat which becomes latent in gasifying the carbon." The reactions are complex, and demand more investigation than has as yet been bestowed upon them. It is certainly true that "steam is not and cannot be a fuel," but it is wrong to conclude hastily that there can be no balance of heat available for increase of the temperature of combustion from the re-combustion of its hydrogen when it has been dissociated under such circumstances. There is another view of the calorific possibilities of liquid fuel to which very little attention has been given, and that is that of the calorific value of the gas (or mixture of gases) into which it may be resolved by a preliminary treatment before being burned in the furnace. From this point of view it will be found that some of the older figures may not have been very far wrong. No doubt the atomising or spraying process is a very convenient and simple method of applying the oil, and the later improvements, which are well set forth by Mr. Booth, have added to the efficiency of this method. But it is not wise to assume that finality has been reached. Mr. Booth will find that the account of the principles of the combustion of coal, which he claims as novel, was recognised and recorded long before his publication of them in the *Electrical Review*. A similar account of these principles has been used by the writer of the volume already referred to, and in other writings, as being well known to chemists and engineers who have studied combustion processes. But the comment of the *Electrical Review* upon Mr. Booth's view cannot be endorsed, because there is nothing more certain than that there is neither solid carbon, solid hydrogen, nor solid oxygen existing in coal. There are solid *compounds* of these bodies, but these are as different from the solid forms of the elements mentioned as water is different from liquid hydrogen and liquid oxygen.

Turning to the practical section of his book, Mr. Booth affords us an excellent view of the varieties in atomisers and systems of burning which have been introduced, and sufficient information as to successful installations of liquid-fuel plant for marine and locomotive work to enable any engineer to understand fully the method of operation and the reasons for the different steps of the process employed. It will certainly not be his fault if liquid fuel is, in future installations, applied unintelligently. F. J. R.

The Metallurgy of Steel. By F. W. Harbord, A.R.S.M., F.I.C. With a section on the **Mechanical Treatment of Steel,** by J. W. Hall, Assoc. M.I.C.E. (London: Griffin & Co.) 25*s*.

Engineers and metallurgists have had equal and ample opportunity of deploring, not only omissions, but, in certain cases, errors in much of the published literature relating to steel. Quite apart, however, from these errors of omission and commission, the wide industrial importance of steel demands an adequate treatment of its metallurgy, and therefore the inclusion of a work on steel in Messrs. Griffin's well-known series is most cordially welcomed. The work will prove all the more acceptable in that it proceeds from the pen of a conscientious metallurgist, who has evidently spared no effort to render his matter not only reliable but well up to date.

The book is divided into four sections, including: (1) "The Manufacture of Steel," by F. W. Harbord; (2) "Reheating," by Harbord and Hall; (3) "The Mechanical Treatment of Steel," by J. W. Hall; and (4) "Finished Steel," by F. W. Harbord. Four valuable appendices conclude the book, including: (1) "Specifications"; (2) "The relation of carbon content to maximum stress"; (3) "Tons and pounds per square inch compared with kilogrammes per square millimetre"; and (4) "The rapid determination of phosphorus and manganese."

The treatment of each section reflects credit on its author or authors, as, in section 2, whilst wordy in places, the matter is, on the whole, telling, and the illustrations are clear. To the student, the works engineer and chemist the book will prove equally

valuable, and it should certainly be in the possession of all interested in the manufacture or working of steel.

That the first edition should be entirely free from typographical error is hardly to be expected—for instance, on page 154 the text reads "silica bricks," which are, however, shown in the illustration (Fig. 142) as firebricks. On page 14 the blast pressure for a modern cupola is stated to be "as much as 2 or 3 lbs. per square inch"—a pressure which appears to be rather high. In future editions the substitution of the term "photomicrograph" for "microphotograph" would also lead to exactitude.

These features are, however, minor ones: turning to the book as a whole, it completely covers the acid and basic steel-making processes, and deals with the chemical reactions involved in both methods. In the Bessemer section various types of small converters are well described, and in a general consideration of these small converters the author states (page 76):

". . . Whatever may be the future of small converter plants, it is in the direction of steel founding that they are most likely to develop, as they cannot hold their own against the large outputs of Siemens or Bessemer plants for ordinary steel manufacture."

—a conclusion in eminent accord with practical experience, and, judging by past experience, small converters are likely to attain quite a distinct position in foundry practice for the production of specially mild castings for electrical purposes.

The Siemens process receives adequate treatment, including various types of gas-producers, the old and new form of furnaces, and various modifications of the furnace and process. Of later developments the Saniter desulphurising, Talbot washing, Krupp dephosphorising, Bertrand Theil, Talbot continuous, Twynam and Monell processes are indicated. In these days all comparisons of the two leading steel-making processes are of moment, and it is therefore interesting to note the authors' conclusions:—

"Comparing the quality produced in open hearth, whether acid or basic, with that of the Bessemer processes, there can be no doubt that the former produces a more regular and reliable material." (Page 206.)

"The average yield of an acid Bessemer plant making rail steel will vary from 86 to 88 tons of steel ingots per 100 tons of metal used, and a basic Bessemer will yield about 83 tons; whereas the acid open-hearth will yield about 97 and the basic about 95 tons per 100 tons of metal charged into the furnace." (Page 207).

This section of the work terminates with a description of steel castings, the production of shear and crucible steel, armour plate manufacture, and various direct processes. Passing from production to manipulation, the next section deals with: (1) "Reheating," and (2) "Handling Material at the Furnaces." In the third section mechanical treatment is exhaustively dealt with; and, amongst other valuable features, descriptions of fluid compression, tube-making and wire-drawing are included. The concluding section contains chapters on mechanical testing, carbon and iron, the influence of elements on the physical properties, special steels, heat treatment, and microscopical examination. Mechanical testing is, within the limits of 35 pages, exceptionally well treated.

Very briefly the scope of the work has been indicated: its extent is shown in the fact that some 738 pages are required to cover it; and, with only one exception, its perusal will be a source of profit to metallurgists and engineers. This exception is found in the chapter devoted to steel castings, which is certainly not in keeping with the otherwise high standard of the book. From a purely foundry point of view the "description of moulds" (p. 214) would have suffered nothing by omission; whilst, from a general one, the "description" is far too scanty, and is also lacking in a grasp of the subject. The two following quotations indicate further matter open to comment:—

Page 213.

"Experience has shown that, provided the metal be sufficiently fluid, it is better to keep the temperature too low rather than too high; and this is one reason why aluminium gives such good results in steel castings, as, by removing oxides and so indirectly increasing the fluidity, it enables the steel to be cast at a slightly lower temperature, and, at the same time, ensures a good surface on the casting."

Page 218.

"The amount of shrinkage varies with the composition and heat of the metal—the softer and hotter the metal the greater the shrinkage; but as smoother castings are obtained from hot metal it is better in many cases where this is of special importance to cast hot and allow for shrinkage."

Taking the first quotation, aluminium in the traces added does *not* increase fluidity; and, owing to the small quantity present in the casting, does *not* aid in the production of a better skin. The production of a smooth skin, as indicated in the second quotation, is a fallacy; for the colder the metal within the limits of fluidity the smoother the surface of the casting—a statement which is almost an axiom in foundry practice. Further, casting temperature should be judged, not by its influence on the "skin," but rather by its effect on the soundness and mechanical properties of the castings.

Some exception must also be taken to a statement on page 603, that there is little danger of absorbing sulphur in the crucible process; for, as a matter of fact, there is every danger of such absorption; hence the necessity for low sulphur coke. It is also hard to

realise that carbon in excess has a tendency to expel sulphur, and furthur demonstration would in this case be acceptable. A feature worthy of careful consideration is found in the following quotation :

"In the author's opinion many of the so-called mysterious failures of steel are due to the original material having been slightly red short during rolling." (Page 608).

—an opinion worthy of careful thought, but failures have nevertheless occurred in acid material notably low in sulphur, and which do not admit of explanation on the grounds of red shortness during rolling.

These features, whilst demanding notice, are, however, alluded to in anything but a critical spirit. The book as a whole certainly ranks high, and its author is to be congratulated in so successfully filling a void in the literature of modern steel metallurgy.—*P.L.*

Modern Engines and Power Generators.—By Rankin Kennedy, C.E. In six volumes. Crown 4to, 9s. net. (London : The Caxton Publishing Company. Vol. I., 216 pp.)

In the first volume of this work the author confines himself mainly to hydraulic machinery—the water turbine, centrifugal pump, pulsometer, and injector all being considered in detail—and to the steam turbine. There is also a chapter devoted to windmills—for pumping purposes mainly—and a short account of the most promising types of rotary engine now on the market.

The purpose of the book is said to be "to explain in the most thorough manner the design and construction of modern Prime 'Movers,' in such a clear manner that any practical engineer can understand and construct the engines, etc., from the instructions given."

Recognising the author's aims, and remembering the class of reader to whom he more particularly appeals, it is evident that a rigorous mathematical discussion of the principles underlying the design of these various prime movers would be out of place in this work, and we are therefore prepared to see the subject treated with the minimum of such mathematical discussion. But in these days of scientific engineering one is at least entitled to demand that an author, who adds yet another to the already large number of books—scientific and popular—which have been written on engineering subjects, should make certain that his mathematical reasoning, even though it may not go very far, is founded on correct hypotheses, and is correct so far as it goes.

Unfortunately this is more than can be claimed for the work in question. Several most elementary errors have crept in, notably in the articles dealing with water jets, and with the flow of steam through an orifice ; where, for example, the velocity of flow is stated to be given by the equation $V^2 = 2gh$, $-h$ being the height of a column of steam equal in weight to the difference of pressure between the two sides of the orifice. While for small differences of pressure this is approximately true, when the differences become large, as in the case of a de Laval nozzle, the results obtained are not within 50 per cent. of the correct values, as obtained from the adiabatic equation. This is one example of the kind of error which we find scattered far too freely throughout the work. In fact, the whole mathematical part of the work needs thoroughly revising.

This is all the more unfortunate, in that the rest of the book, dealing as it does in detail with the construction of the machines considered, can be given unstinting praise. The chapter on steam turbines is, of course, of most interest in view of the prominent position they at present occupy with most engineers, and while the author — rightly considering most other turbines to be merely a slight modification of either the Parsons or de Laval type—confines himself largely to the consideration of these types, yet, by the inclusion of the Stumpf and the Curtis turbines, it will be seen that this part of the work is quite in touch with the latest developments in design.

Of course, in a work of this kind, it is impossible to give exact details as to width of blades and width of openings in vanes, etc., for maximum economy, such knowledge —forming a considerable part of the assets of the large turbine makers—being of course kept as secret as possible.

In the article, too, on the propulsion of vessels by water jets, as well as on the construction of water turbines, and centifrugal pumps, the author speaks from long experience, so that his conclusions are always worthy of study even, if occasionally—as in the case of jet propellers—we cannot accept them as they stand.

The book throughout is well and copiously illustrated, and in conclusion, if only the mathematics of the work were revised, we could confidently recommend it as an addition to any engineer's library. A. H. G.

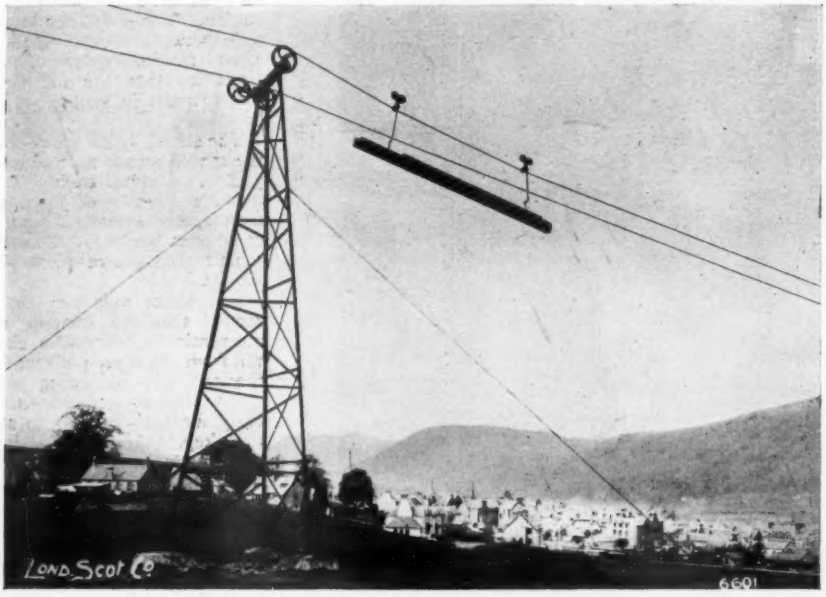
ENGINEERING PROGRESS.

Aërial Ropeway at Aberfeldy.

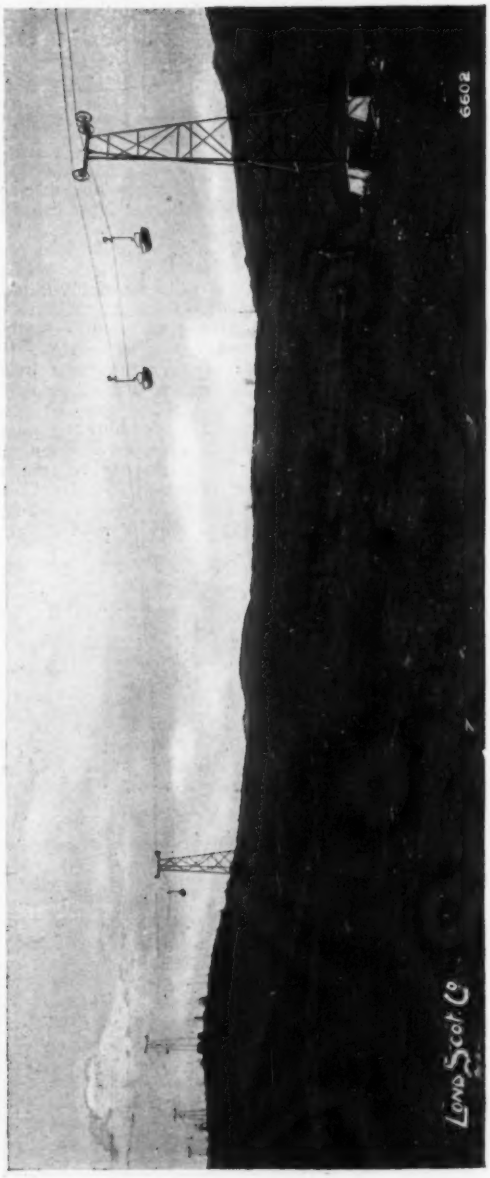
THE opening of the first installation of aërial ropeway traction for a Public Board in Scotland, and the largest of its kind in Great Britain, was the occasion of a recent interesting ceremony which was performed by Mr. W. Steuart Fothringham, of Murthly, Chairman of the Highland District Committee of the Perthshire District Council.

It is to the enterprise of this committee that the scheme owes its existence. It appears that the whole of the whinstone quarries in the district of Athol, Dunkeld, Murthly and Strathbay, with but one exception, are situated high up on the hills, thus involving a heavy and expensive cartage on the roads, which were unsuitable for such traffic. This meant a further large expenditure for maintenance and repair.

The committee's road surveyor, Mr. Wm. Bell, C.E., pointed out that cartage of road metal from the quarry to Aberfeldy railway station cost the committee at the rate of 2*s.* 6*d.* per ton, in addition to the considerable sum spent every year in repairing the road. A charge of 9*d.* per ton is being calculated on for carrying the materials by the ropeway, but the working goes to show that 6*d.* per ton will probably be found sufficient to cover all expenses and upkeep of the ropeway in a thoroughly efficient manner. As the Highland District Committee serve 136 miles of roads, and use annually about 3,500 tons of road metal, a



VIEW OF THE ABERFELDY ROPEWAY: A TIMBER LOG IN TRANSIT.



ANOTHER PORTION OF THE ABERFELDY ROPEWAY.

considerable sum per annum will be saved by the committee in using this improved means of distribution.

The scheme in itself was so feasible that the committee readily adopted Mr. Bell's advice, and a contract was entered into with Messrs. J. M. Henderson & Co., Aberdeen, for the construction of a ropeway with sufficient engine-power — 25 horse—to drive it, a breaking machine at the quarry end and a rock drill. The ropeway, which is about two-and-a-quarter miles in length, is carried on 37 lattice steel trestles varying in height between 25 ft. and 40 ft., which carry the requisite carrier pulleys for ropes.

The trestles are spaced at intervals of 100 yds. There are altogether 100 carriers and buckets, which are filled from a stone-breaker near the loading terminal at Gatehouse quarry, the metal being delivered into wagons from the unloading terminal at Aberfeldy railway station. The difference in altitude between the terminals is 1,000 ft. in favour of the loads, so that the full skeps largely assist in hauling up the empties.

The skeps, which are of steel, are spaced at 280 ft., and carry 3 cwts. of metal each. They travel at the rate of 300 ft. per minute, and have a total capacity of 10 tons per hour. The terminals are built of pitch pine timber.

The shunt rails are so arranged that the carriers run automatically on to the shunt rail from the rope, and round to the loading or unloading point, where they slow down sufficiently for the operator to stop the skep, after which a slight push sends the carrier and skep along the shunt rail on to the out-going rope, the carrier fastening itself automatically on to the rope as it leaves the terminal. This enables the working to be conducted with the minimum amount of labour.

A 25-b h.p. horizontal steam engine supplies power for driving the ropeway, a large stonebreaker and an air compressor, steam being provided by a horizontal multitubular boiler working at 100 lbs. pressure.

After being quarried, the stone is deposited on a platform placed above the breaker, whence, on being broken, screened and sorted into sizes, it falls into a series of bins, the mouth of each of which is arranged so that the material pours directly into the ropeway buckets hanging on the shunt rail. Provision is made at the Aberfeldy end for the storage of several hundred tons of broken stone in various sizes, the storage receptacles being arranged so that the material is tipped directly into them.

In addition to bringing stone down from quarry, the ropeway carries the coal from station to quarry for the steam boiler, and a special hoist is arranged for conveying coal direct from the railway wagon to the skeps on the shunt rail at the lower terminal.

Mr. William Bell, C.E. and surveyor, Aberfeldy, represented the Highland District Committee during construction; Mr. W. N. Colam, M.Inst.C.E., undertook the consulting work; the designs throughout were made by Messrs. J. M. Henderson & Co, and after preparation of the materials and parts at their works, the erection of the ropeway was superintended by Mr. J. H. Ducat, under Mr. Henderson's supervision.

New Air-Valve Drill.

A NEW type of drill recently designed and introduced by Messrs. Holman Brothers, of Camborne, and received with great favour, is illustrated in longitudinal section in the accompanying figure. It will be seen that the leading feature of the apparatus consists in the new valve arrangement. Referring to the illustration, *A* is the cylinder in which is fitted the piston *B*, having inclined shoulders *H H*, by which the ball valves are operated. *C* is the valve chest, in which is the main valve. E^1 E^2, F^1 F^2 are supplementary ball valves which control the movement of the main valve *D*, and are operated by the inclined shoulders of the piston, whereby the ends of the valve chest *C* are alternately placed in communication with the main exhaust.

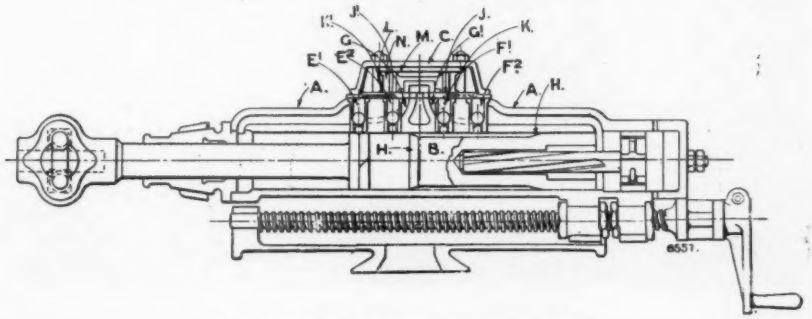
The main valve is of the piston type, which by its movement places the ports *G* and G^1 alternately in communication with the fluid pressure, this being effected by the shoulder *H*, which lifts the ball valves and exhausts the valve chest ends. By using two sets of supplementary valves on each end expansive working is obtained. When the piston moves forward from the position shown in the sketch, and lifts the valve F^1, it exhausts that end of the valve chest, and the main valve travels as far as the exhaust port *J* and covers it. The exhaust being now closed the valve is stopped in the position shown, whereby the air supply is cut off.

Continuing its movement by the expansion of the air, the piston valve opens F^1, which exhausts the end again through the hole *K*, and the valve travels to the end of the valve chest and reverses the motion of the piston.

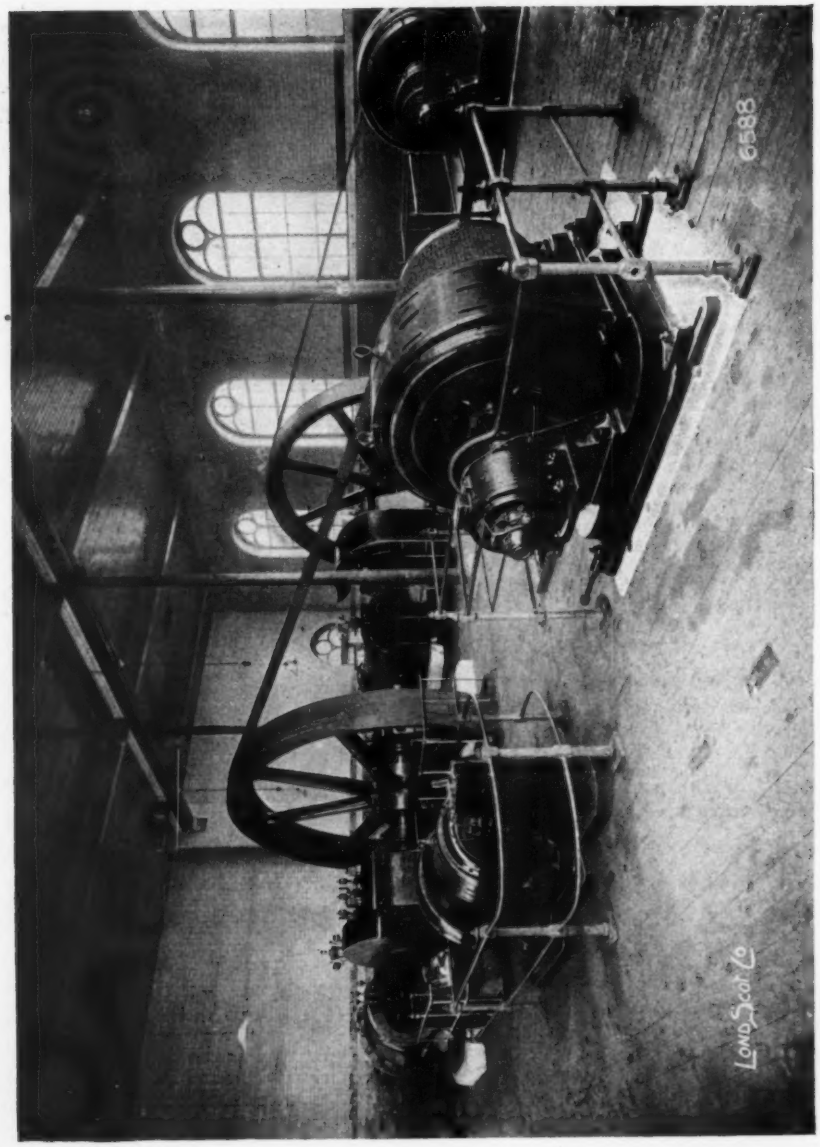
The drill is made in the following sizes, viz. $2\frac{1}{2}$ ins., $3\frac{1}{4}$ ins., $3\frac{1}{2}$ ins. and $3\frac{5}{8}$ ins., and will work from 7-in. to 1-in. stroke.

Coke-Oven Gas-Driven Electrical Installation at Tingley Collieries.

THE illustration on page 278 is that of a very interesting installation of gas engines recently installed at the Yorkshire Iron & Coal



DETAILS OF MESSRS. HOLMAN'S NEW AIR-VALVE DRILL.



COKE-OVEN GAS-DRIVEN ELECTRICAL INSTALLATION AT TINGLEY COLLIERIES.

Co's. collieries at Tingley, near Leeds, under the direction of their managing director (Mr. James Riley), by Messrs. Richardsons, Westgarth & Co., Ltd., of Middlesbro. This is, we believe, the first installation of large size put down in this country with gas engines using coke-oven gas. The engines are worked by the surplus gas from a battery of forty patent coke ovens, and, as will be seen, drive dynamos which are used for generating power for the underground haulage and lighting of the pits, and for various requirements at bank.

The engines are of the well-known "Cockerill" type, of which Messrs. Richardsons, Westgarth & Co. are the sole makers in this country, each engine being 250 indicated horse power when running at the normal working speed of 120 revolutions per minute. This installation has now been at work for some months, with, we understand, very satisfactory result.

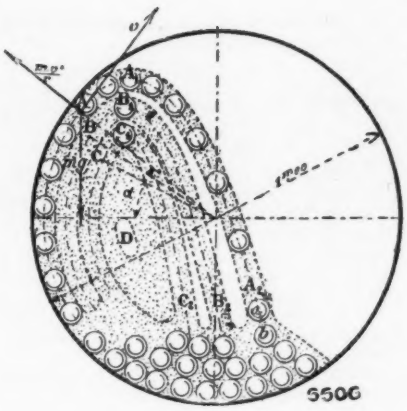


DIAGRAM SHOWING PATHS FOLLOWED BY THE BALLS.

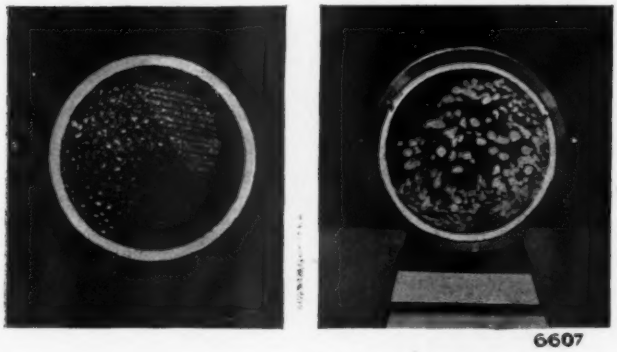
The Action of Ball Mills.

THE action of ball mills, the employment of which is largely on the increase, especially in the manufacture of cement, has only recently been investigated in a methodical manner. This type of apparatus consists, as is generally known, of a drum or cylinder revolving on its longitudinal axis, in which is introduced the material to be pulverised, and a number of balls prepared from some hard material.

The shock of the balls reduces the substance to be treated to fragments, and when ground to the requisite consistency the material is withdrawn from the end opposite to that at which it was introduced. The length and diameter of the drum, the weight and number of the balls, the speed of rotation, are the variable elements at the disposal of the designer for rendering the operation as rapid and economical as possible. The following particulars, obtained from a series of experiments conducted by M. Fischer at the Krupp Works, and reported in the *Zeitschrift des Vereines Deutscher Ingenieure*, may prove of interest.

A drum 1 m. in diameter was used, in which were placed balls 6 cms. diameter, occupying the drum to a height of 0·45 m.

The balls commenced to rise on the periphery of the drum when the latter attained a speed of 25 revolutions per minute, and as this was increased the balls were projected from the side at which they had been drawn up by the motion to the lower part of the drum. The accompanying figure shows the path followed by the different layers of balls as they become more and more removed from the periphery.



THE ACTION OF BALL MILLS.

1. 32 REVOLUTIONS PER MINUTE. 2. 66 REVOLUTIONS PER MINUTE.

In principle a ball A becomes detached from the drum wall when

$$mg \sin a = \frac{mv^2}{r},$$

and follows a trajectory A, A_1, A_2, defined by

$$y = x \frac{\cos a}{\sin a} - x^2 \frac{g}{2v^2 \sin^2 a}.$$

Pulverisation is produced principally by the shock of a ball a striking another b, and in order that the force of this impact should be as great as possible, it is necessary to regulate the speed of rotation so that the balls are carried round by the wall of the drum to a maximum height at which they can be precipitated downwards and not carried right round, in which case, of course, no useful effect would be obtained.

According to the author, the formula for speeds giving the best results is as follows :—

$$n = \frac{32-35}{\sqrt{D}},$$

where D = diameter of the cylinder metres and n the number of revolutions per minute. The density and hardness of the balls are regulated by the material to be treated.

A New Coil Clutch.

THE stress and torsion consequent upon the sudden starting of heavy machinery, and the requirements of a first-rate clutch to minimise the same, have evidently been fulfilled in the very excellent form of clutch placed upon the market by Messrs. Coupar, Schwartz & Co., of Barnsley. The mechanical effort obtained by the clutch is based upon the principle of the capstan or coil wound round a cylinder or drum. The latter A, as shown at Fig. 1, is a parallel coupling or busk having a chilled surface accurately finished, and represents the body

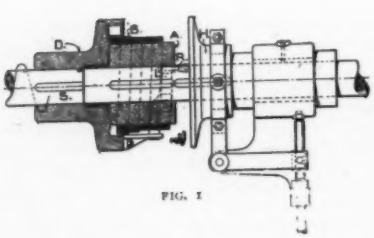


FIG. 1

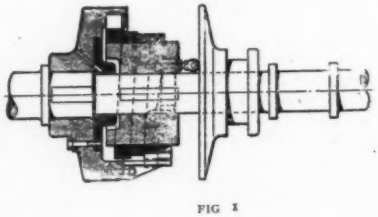


FIG 2

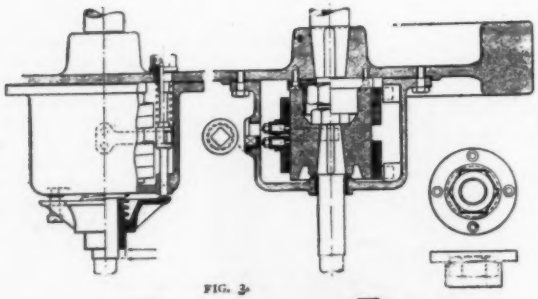


FIG. 3.

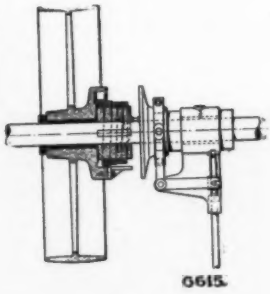
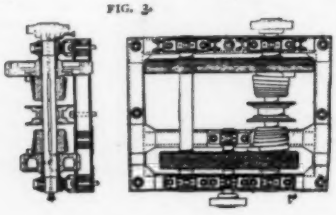


FIG. 4.



COIL CLUTCH.

of the capstan. A soft steel coil *B* is bored internally to fit the chilled cylinder, one end being bolted to the driving-disc *D* keyed on the driven shaft *S*. The tail end of the coil is left free, but to the two last convolutions a wrought-iron lever *L* is bolted. This carries a forked rod *R*, having a friction-bowl revolving on a pin passing through the fork. The pressure is effected by a sliding-disc *H*, which is forced against the bowl by a lever arrangement operated by screw and hand-wheel. This arrangement is very sensitive and can be regulated to a nicety, and thus all jar, as associated with the old type of claw-clutch, is entirely eliminated. The end of the driving-shaft projects as shown for some few inches through the cylinder, and is free to revolve within the recess formed in the driving-disc *D*. This secures perfect alignment of the two shafts, driver and driven, and forming, as it were, a continuous bearing. The particular type of clutch shown at Fig. 1 is applicable to and suitable for all open drives as an ordinary clutch ranging from ½-in. to 22-in. diameter shafts, and transmitting from 1 to 10,000 h.p. A similar type (Fig. 2) is largely used for rolling-mills and other heavy drives; the ones shown in plan and end elevation at Fig. 3 being the method of arranging the same for reversing purposes. It will be noticed that in conjunction with the clutch arrangement for heavy drives it is advisable to have solid collars on the shafts to support the driving-disc against end pressure. Fig. 4 shows the application of the clutch to a single-belt pulley. In this case the boss of the pulley is increased on the one side to form the driving-disc against which the coil is bolted. This arrangement permits of the pulley being fixed on a line-shaft and used as a direct drive from shaft to machine, so dispensing with counter-shafts or other auxiliaries. In dusty or exposed situations, or where the parts are likely to be affected by moisture, a provision is made by enclosing the whole of the clutch in a damp- and dust-proof casing. This is shown at Fig. 5, the casing being bolted to the plate of a wheel, which may be a spur-gear or a modified form of fly-wheel. The closing of the coil is effected by the pressure of the disc (shown on the right) against the end of the stud *S*, which is extended through the casing. A bearing for the stud is made at each end of the casing, and a relief spring at the lower end provides against any possibility of the coil remaining closed. Similarly, a spring is inserted in the outer driving-disc to assist its release. In the enclosed form of clutch the cavity is filled with a thick oil or other heavy lubricant. As a proof of the efficiency of the coil clutch it may be stated that during the last two years upwards of 300 have been supplied, ranging from 200 to 2,500 h.p.; and recently two of 1,500, two of 3,200, and two of 4,000 h.p. have been constructed for Messrs. Krupp's works at Essen. They are being extensively used for rolling-mills up to 8,000 h.p., as their introduction has been found to be the most economical; an engine or motor of 400 or 500 h.p. with heavy fly-wheel developing sufficient energy to roll down the largest ingots at about one-third of the cost of a reversing-engine.

—•—

The Specific Heat of Superheated Steam.

AMONG the many problems which the use of superheated steam has brought to the attention of the engineering profession, one of the most important is that of determining the actual amount of heat present in such steam.

Until recently, Regnault's empirical formula for the total heat of saturated steam, with the addition of a term giving the extra heat used in superheating, has been adopted, the formula then becoming

$$H = 1{,}091{\cdot}7 + {\cdot}305\,(t - 32) + C_p\,(t_s - t).$$

H being the total heat in the steam reckoned from 32 degs. Fahr., and C_p being the specific heat of superheated steam (assumed constant and equal to ·48).

Recently, however, it has been repeatedly shown, both by mathematical reasoning and by experiment, that the specific heat cannot be constant for all temperatures.

Greissmann, in particular, has recently completed a series of experiments (122 in all), which give very consistent results, and which agree very well with results obtained by Dr. Grindley in 1900.

The complete data and results of these experiments have been published in the *Zeitschrift des Vereines Deutscher Ingenieurs*, and these results, along with determinations by other observers, are plotted in Fig. 1.

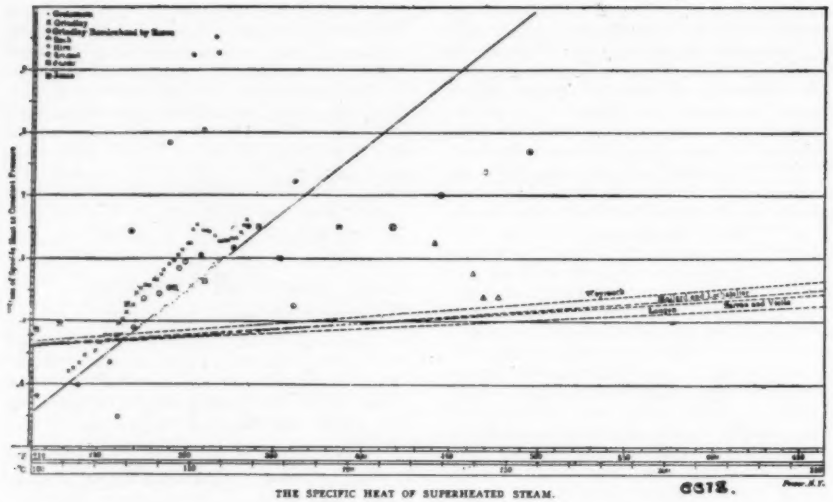
Taking Greissmann's values as a basis, the instantaneous value of the specific heat of superheated steam may be represented by the formula, $C_p = {\cdot}00{,}222\,t_s - {\cdot}116$; t_s being the temperature in degs. Fahr. of the superheated steam. The mean value of the sp. heat between saturation, and any degree of superheat, would be found by the formula

$$C_p = {\cdot}00{,}222\,\frac{(t_s + t)}{2} - {\cdot}116\,;$$

Introducing this value for the sp. heat the formula for the total heat of the superheated steam becomes :—

$$H = 1{,}091{\cdot}7 + {\cdot}305\,(t - 32) + {\cdot}00{,}111\,(t_s^2 - t^2) - {\cdot}116\,(t_s - t.$$

As regards the generation of



THE SPECIFIC HEAT OF SUPERHEATED STEAM. 6378.

superheated steam, a most interesting report appeared in the same paper, taking into consideration the material required in the construction of superheaters, the transmission of heat through the surfaces of the superheaters, the velocity of the steam through the pipes, and the work done by the boilers in the generation of the steam.

Experience shows that the adaptability of cast-iron as a material of construction depends entirely on its chemical composition: at least, at the present time, only one kind of cast-iron superheater—the "Schwoerer"—has stood the test of time. Many of these superheaters have been working for ten years and more, with steam at 500 degs. Fahr., and the average yearly expenditure in repairs to piping and brickwork in connection with the same, taken over a large number of superheaters, all of which have been working for more than ten years, works out to about 4s. per element. Cast-iron, too, will stand a much higher degree of heat without injury than will wrought-iron, and this property obviates the necessity for any damping mechanism, and does not endanger the superheater as a result of carelessness.

The method of installation of the superheaters, with reference to the direction of flow of the hot gases and steam over the heating surfaces, has a great influence on the rate of transmission of heat. This may be observed when using coal having a high ash percentage, and with a horizontal superheater surface. The result of one test showed a drop of 104 degs. Fahr. in the steam temperature in three days due to the heater surface being covered with ash. In general, vertical surfaces placed perpendicular to the direction of flow of the hot gases are found to be much more efficient.

In choosing the velocity of steam, through the superheater, the heat transmission, durability, and drop in pressure must be taken into consideration. For durability, large velocities are required; as, in order that the temperature of the superheater surface should not exceed a degree affecting its durability, it is necessary that a certain weight of steam should pass in unit time.

Experience shows that a velocity of about 60 ft. per second is most suitable, though this depends to some extent on the area of the tubes and on the weight of steam passing in unit time.

The style of superheater, and of its connection with the boiler, bear the greatest influence upon the heat efficiency.

By making a comparison of the efficiency of an installation with superheater, with that of the boiler alone, we are enabled to judge as to the influence of the moisture in the steam. Experiment shows that the efficiency of the entire installation, is slightly less than that of the boiler alone. Experiments with the same boiler, fitted first with boiler-flue superheater, and then with separately fired superheater, show that whereas the former shows a heat efficiency 6 per cent. greater than that of the boiler alone, the latter

shows an efficiency 5 per cent. less than that of the boiler alone.

There are two causes affecting the boiler duty, due to the direct connection of the superheater with the boiler. First, the change in temperature difference between the flue-gas and the water in the boiler, and, second, the alteration of grate surface elements, upon which the efficiency of the boiler depends to a large degree.

The change in temperature difference is greatest when the superheater is located at the end of the grate area. Consequently the boiler efficiency is favoured by installing the superheater as far to the rear as possible. With such an installation, the designs must provide sufficient heating surface, and care must be taken that the difference between the temperature of the flue-gases and of the steam is sufficiently great to dry and superheat the steam.

In choosing the location for the superheater, not only must the size of the superheater, but also the boiler-heating surface be taken into consideration. Superheaters located at the end of the boiler require the largest superheater, but the smallest boiler-heating surface. With superheaters installed in the flue, the boiler requirements can be increased about 50 per cent. without affecting the boiler efficiency. It is therefore almost impossible to instal effectively, under ordinary conditions, a superheater into the flue of an existing boiler-plant. The existing grate areas, flue areas, and draught will be insufficient in most cases ; and this is, in all probability, the reason for the bad reputation which this method of installation has earned.

An Experimental Double-Acting Petrol Engine.

An interesting type of a double-acting petrol engine, embodying an ingenious arrangement of parts, has been constructed by Mr. W. B. Burchall, of Bredbury. As in the case of large power internal-combustion engines, many difficulties have been in the way of designing a satisfactory petrol engine, operating on the double-acting principle, these troubles being chiefly centred in the piston rod, which is liable to become excessively overheated ; in the stuffing box, which is difficult to keep gas tight ; in the frictional resistance set up by the gland ; and, finally, in the case of small engines, in the tendency of the piston itself to become much overheated, thus increasing the risk of pre-ignition.

From an inspection of the drawings of the Burchall engine, these difficulties would

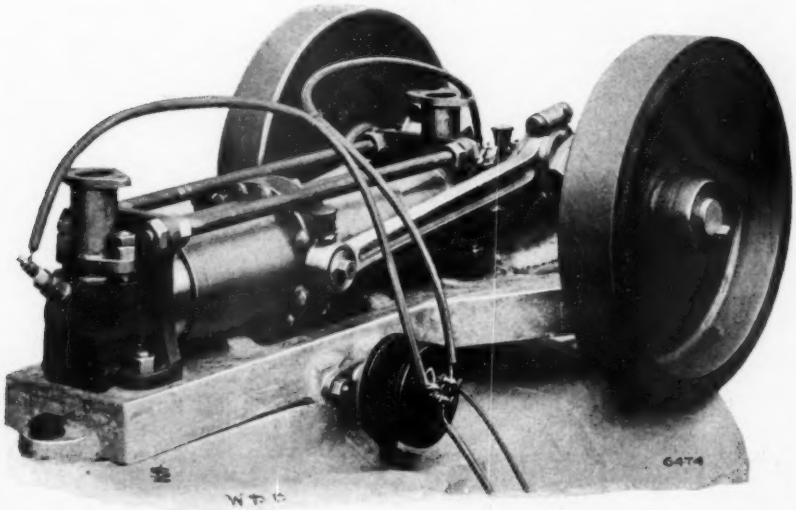


FIG. 1.—"BURCHALL DOUBLE-ACTING PETROL ENGINE: SIDE VIEW

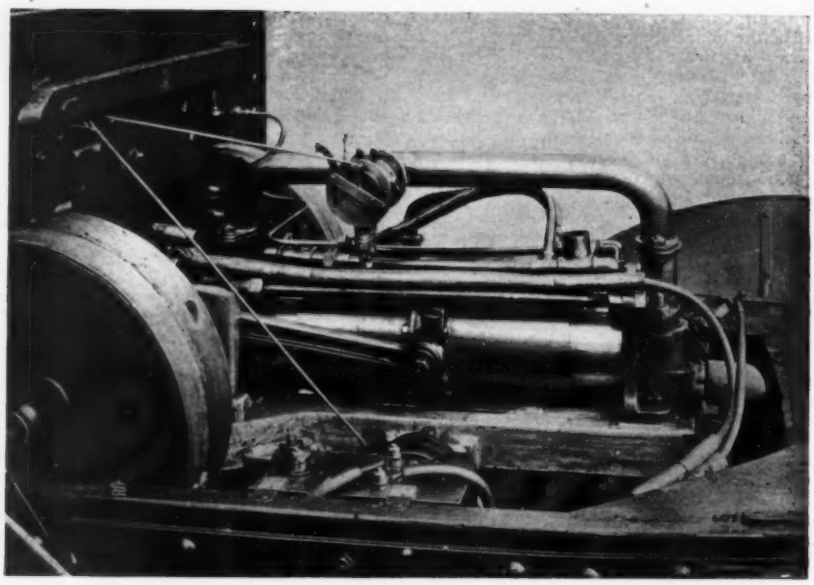
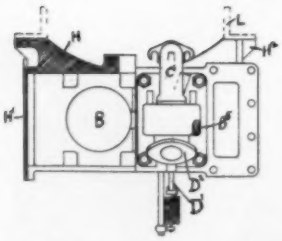
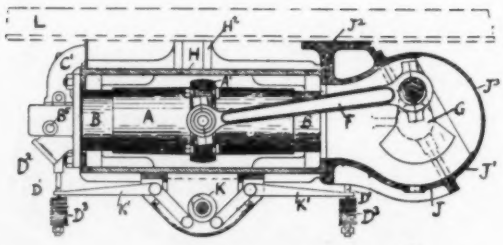
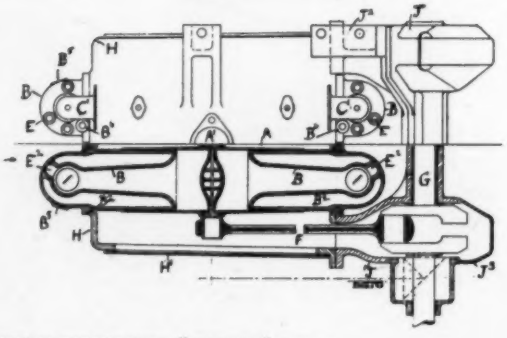


FIG. 2.—THE ENGINE FIXED ON CAR.





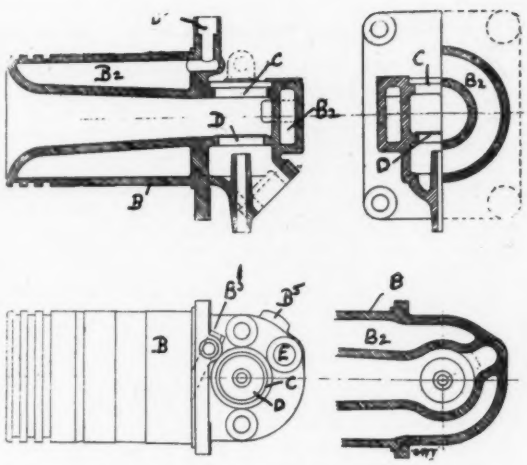


A Cylinders.
A[1] Carrier.
A[2] Gudgeon pins.
B Fixed piston castings.
B[2] Water-jackets.
B[3] Cooling water inlets.
B[4] Cooling water outlets.
C Inlet-valve seatings.
C[1] Induction-pipe fittings.
D Exhaust-valve seatings.
D[1] Exhaust-valves.
D[2] Exhaust-pipe flanges.
D[3] Exhaust-valve springs.
E Ignition-plugs.
E[2] Pockets in combustion chambers for ignition-plugs.
H Casing enclosing cylinders.
H[1] Side cover-plates.
K Cam-shaft.
K[1] Levers operating exhaust-valves.
L Angle members of main frame.

FIGS. 3 TO 5.—DETAILS OF TWIN-CYLINDER "BURCHALL" ENGINE.

appear to have been overcome; and, in fact, the inventor claims that in actual working first-class results have been secured, both in the shop and on a motor car on the road.

The details will be readily followed by the aid of the illustrations, of which Figs. 1 and 2 are views of a single-cylinder type, while Figs. 3-9 show the construction of a twin-cylinder engine. Both engines operate on the Otto four-stroke cycle and have a bore and stroke of 4¼ ins., the normal speed being 800 revs. per minute. The larger engine, which is expected to develop 20 b h.p., weighs 236 lbs. (including the fly-wheel), and its outside dimensions are: Length, 31 ins.; width, 18 ins.; and depth, 13½ ins.



FIGS. 6 TO 9.—DETAILS OF STATIONARY PISTON, "BURCHALL" ENGINE.

Referring to the illustrations, it will be seen that the principal feature of the engine consists in the unusual arrangement of the cylinders and pistons. Instead of the pistons reciprocating in a fixed cylinder, they are stationary and in line with one another, the sleeve-like cylinder sliding to and fro over the pistons, in which latter the combustion chambers are formed. These are provided with the usual valve chambers. The cylinder is divided centrally into two distinct compartments by a forging on which project gudgeon-pins from which the connecting-rods pass to the crank-shaft. The connecting-rods can thus be detached without removing either the cylinders or pistons; and their length, which is obtained without involving any extra length of engine, is such, as to secure a small maximum obliquity and lessened wear at the small end brasses. Such is the arrangement, whereby the usual piston and rod-stuffing box, gland and cross-head have been dispensed with, and by which the weight of the reciprocating parts has been kept down to a minimum. The piston casting has formed in it a jointless water-jacket of large size, which passes round the valve chamber also. Pistons and cylinders are made to $\frac{1}{1000}$-in. fit, and yet work freely when heated, owing to the cooler member being an internal one. The cylinders travel to within ⅛ in. of the end of the pistons, and this motion suffices to keep them cool. External air cooling is not absolutely necessary, but on the new design all the moving parts of the engine are protected by a dust-proof casing, through which the air supply is drawn by the carburetter. This air-current keeps the cylinders cool, and also assists carburation. On the experimental engine the valve chambers are fitted with atmospherically operated inlet-valves on the upper side, and mechanically operated exhaust-valves immediately beneath them. The latter are operated from a cam-shaft that lies beneath the engine, and the commutator and low-tension distributor are fitted on one projecting end of the cam-shaft. This shaft is driven by a chain off the crank-shaft, but in the larger type bevel gearing has been substituted. By the arrangement adopted for the levers, each cam is enabled to operate the corresponding valves at opposite ends of the same cylinder; so that, even when the inlet valves are controlled mechanically, two cams only are required for actuating four valves.

The carburetter, seen on right side of induction-pipe is of the needle-valve type, in which the inrushing charge impinges on a disc, and the needle is lifted from its seat, allowing the petrol to pass to the mixing chamber.

The mixing chamber is provided with an internal sleeve in which are ports, and as these come opposite to corresponding ports in the wall of the chamber, a greater amount of air is allowed to pass into the chamber while, at the same time, the port under the needle disc is closed.

By this means there is no throttling of the charge in the carburetter, and the speed of the engine can be controlled by variation in

strength of mixture; the full compression thus obtained enables a weak charge to be fired.

A throttle valve of butterfly type is also fitted, so that the engine can be utilised as brake.

The ignition is of the usual high-tension type with accumulators. A single coil, with Charpentier trembler serves for both ends of the cylinder, the commutator serving both to time the make and break of the primary current and to switch over the secondary to the ignition plugs at each end.

The water circulation is from a centrifugal pump driven by the fly-wheel at the far side of the engine, and an outlet pipe is laid above it, returning to a tank underneath the seat.

—♦—

Electric Coal Haulage at Huddersfield.

THROUGH the courtesy of Mr. J. C. Whiteley, chief engineering assistant to the Huddersfield Corporation Tramways, we are able to give some photographs and particulars of an interesting development in coal haulage and tramway enterprise.

Owing to the heavy nature of the roads in Huddersfield the system of horse haulage was rendered very costly, and as far back as three years ago the idea of utilising the tramways, which at that time were worked by steam power, for hauling coal was considered; and, in fact, provision for this was included in the various Huddersfield Acts.

When, about this time, Mr. H. N. Thomas, M.I.E.E., was appointed general manager of the tramways department, negotiations were commenced with the joint railway companies with a view of hauling coals to a mill situated about four miles from the coal sidings and belonging to Messrs. Martin & Sons, Ltd., who were prepared to enter into an agreement with the tramways committee. Six months ago these negotiations were brought to a successful termination, and the work of designing a suitable truck was put in hand. In preparing the design, consideration had to be paid to the position of the sidings which were situated in a very awkward corner, and also to the question of head room, the shoots being only a little over 7 ft. high.

The wagon, the body of which closely resembles an ordinary coal truck, is of 10 tons capacity, and is mounted on a Brush radial truck. It is equipped with two Westinghouse motors of 45 b.h.p. each, and also a Westinghouse Newal magnetic brake. A hand brake and sanding apparatus have also been fitted.

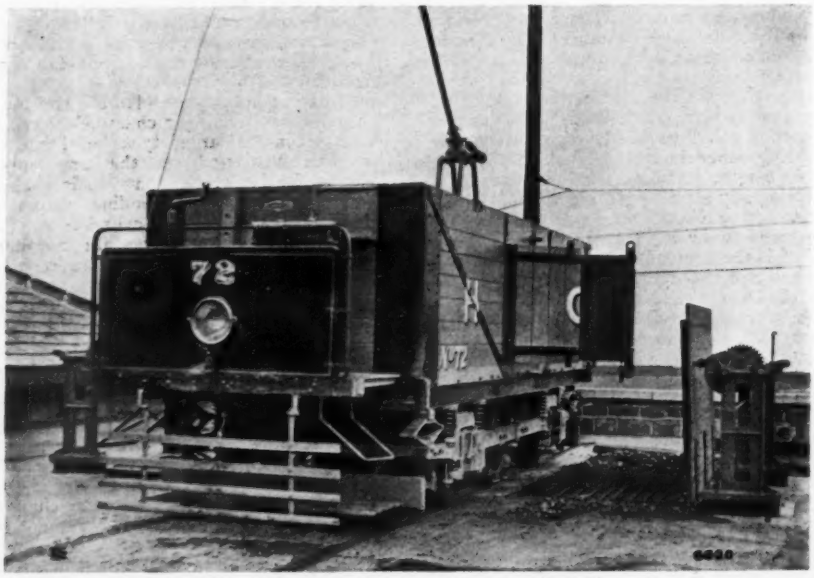


FIG. 1.—ELECTRICALLY-OPERATED COAL WAGON

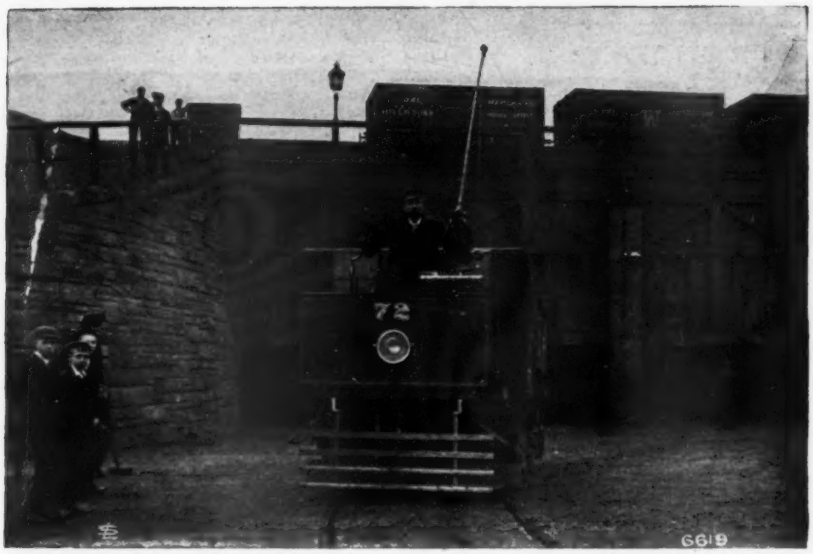


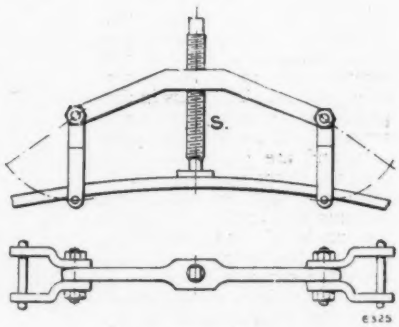
FIG. 2.—WAGON LEAVING RAILWAY SIDING

The body was built by Messrs. Milner, Voss & Co., of Birkenhead, the complete design being the work of Mr. H. N. Thomas, the late tramways manager.

The car is now successfully at work conveying coal regularly to the mill, and we understand that the corporation have already made provision for extending the scheme.

Setting Rings.

The illustration shows a very useful appliance for setting rings, which are required to be as near a true circle as possible (without being turned), as in the case of roller rings for gun-mountings. The screws are worked by a single-ended wrench. The arms are held together by a bolt and nut, and are left free to turn. By the careful use of trammels and this appliance, rings may be set to a fairly true circle. Of course, it may be used to set either out or in as required. A. B.



SETTING RINGS

RAILWAY NOTES.

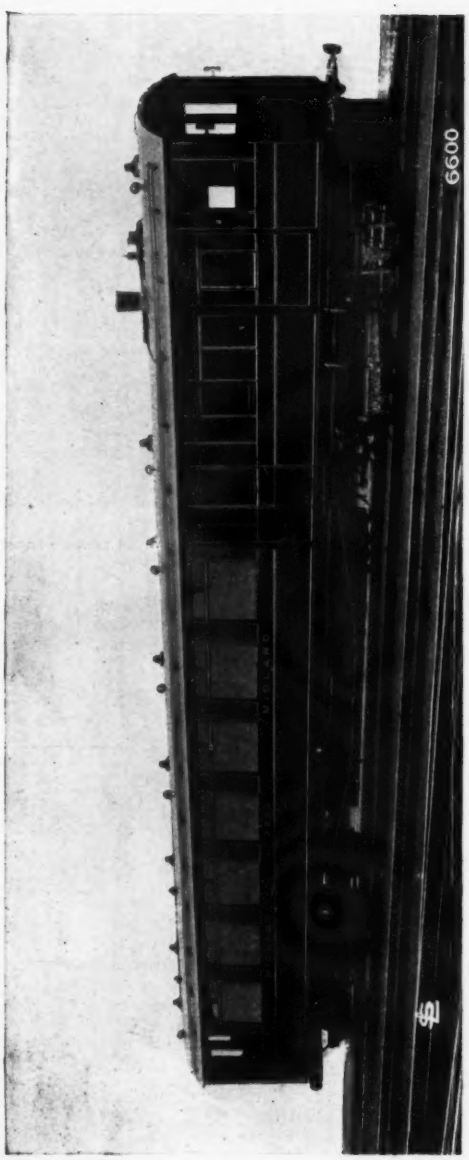
Steam-Motor Coaches for the Midland Railway.

FOLLOWING the example of the London & South Western, Taff Vale, and other companies, the Midland Railway have recently put into service two steam-motor coaches, for branch-line traffic.

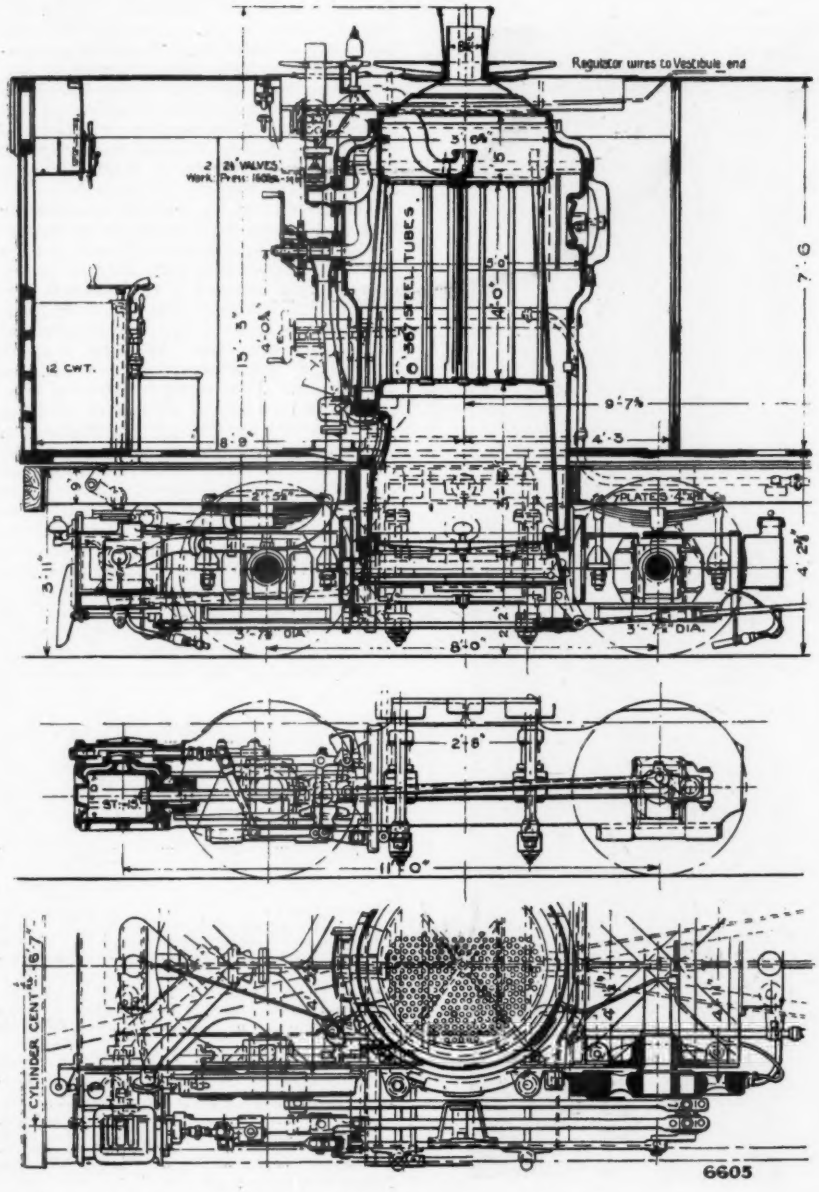
They have been constructed at the Midland works at Derby, from the designs of Mr. Deeley, the locomotive superintendent, and Mr. Bain, the carriage and wagon superintendent to the company, and are now running between Heysham and Morecambe. The accompanying illustrations show a view of one of the coaches and details of the engine and boiler.

The coach is divided into four sections, viz.: the engine-room, passenger compartment, luggage compartment and vestibule, having the following dimensions respectively, viz., length: 13 ft., 6 ft. 6 ins., 35 ft., 4 ft. 6 ins., totalling about 60 ft. over the end panels. The width outside the saloon is 9 ft., and outside the engine-room, luggage compartment and vestibule, 8 ft. 6¾ ins.

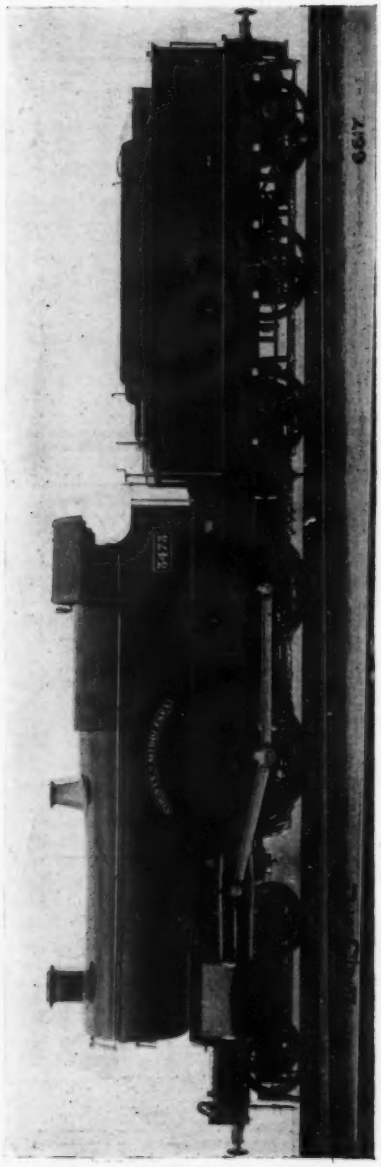
The seating capacity in the saloon is 55 passengers; and, in addition, folding seats have been arranged in the luggage compartment to accommodate eight persons. The seats in the passenger compartment are arranged transversely on each side, and are separated by a gangway running the whole length of the saloon. The bottoms and backs of the seats are made of perforated sycamore. Entrance to or exit from the car is effected by a door in the compartment next the engine-room, or by one at the vestibule end. A



STEAM-MOTOR COACH: MIDLAND RAILWAY



STEAM-MOTOR COACH, MIDLAND RAILWAY: DETAILS OF ENGINE AND BOILER.



4-4-0 TYPE EXPRESS LOCOMOTIVE, "COUNTY CLASS," GREAT WESTERN RAILWAY.

sliding door gives access to the saloon from the vestibule, and a hinged door from the luggage compartment. Doors at each end have been provided for through communication when a trailer coach is attached.

Steel channels and bulb angles have been used for the frame, which is carried on two bogies, the one at the vestibule end being of the ordinary carriage Midland standard type, that at the engine end being of special design and carries the boiler.

The latter is of the vertical multitubular type, and is designed to work at a pressure of 160 lbs. to the square inch. There are two 11-in. steam cylinders with a 15-in. stroke operating the rear pair of bogie-wheels, side rods giving connection to the front pair. The valve gear is of the same type as that in use on the Great Western Railway Company's steam-motor carriage, viz. the Walschaert. The water for the boiler is supplied from a tank of 500 gallons capacity, carried on the underframe between the bogies. The vehicle can be started and stopped from either end of the car, the starting and stopping apparatus being duplicated to allow this to be done. A series of endless wire ropes carried over the outside of the roof of the carriage forms the connection between the steam regulators at each end ; and by means of a compensating lever any slack or tension in the rope caused by the movements of the vertical and lateral movements of the engine bogie when rounding curves, etc., is taken up.

The following are the leading dimensions :—

RUNNING GEAR:	
Wheels, diameter	3 ft. 7½ ins.
WHEELBASE:	
Bogie	8 ft.
C. to c. of bogies	42 ft.
Total	50 ft.
WEIGHT:	
Empty	32 tons 6 c. 1 q.
Loaded	36 tons 1 c 1 q.
BOILER, Type:	Vertical, multitubular, fire tube.
Working pressure	160 lbs. per sq. in.
Length between tube plates, inside ...	4 ft.
Diameter outside top ring	5 ft.
Diameter outside bottom ring	4 ft. 4 ins.
FIREBOX:	
Height of shell, outside	3 ft. 6 ins.
Diameter of shell, inside ...	3 ft. 9⅛ ins. at bottom.
" " " ...	3 ft. 5½ ins. at top.
TUBES:	Steel.
Number	387
Diameter, outside	1¾ in.
HEATING SURFACE AND GRATE AREA:	
Tubes	456 sq. ft.
Firebox	42 sq. ft.
Total	498 sq. ft.
Grate area	11'3 sq. ft.
MISCELLANEOUS:	
Speed	30 mls. p.h.
Tractive power	5,000 lbs.

New 4-4-0 Type Express Locomotives.

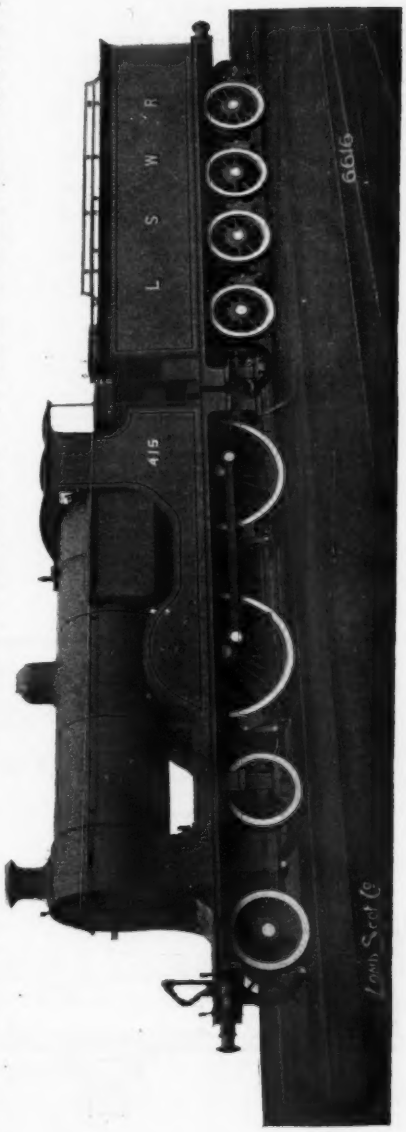
THE Great Western Railway Company have at present under construction at their Swindon works a number of outside-cylinder four-wheel coupled type locomotives destined for working their long-distance fast express traffic. The first of this class is illustrated herewith, our acknowledgments being due to Mr. G. J. Churchward, M.I.Mech.E., Chief Mechanical Engineer of the company, for the photograph and accompanying details. The "County" class differ from their predecessors the "City" class, in respect of cylinders, which, although of the same dimensions, are in the latter class placed inside the frames; also as regards the bogie wheels, which have been reduced in diameter to 3 ft. 2 ins. as against 3 ft. 8 ins.

The exigencies of increased speed and weight have also led the London & South Western Company to undertake the construction of a new series of powerful express engines, an illustration of the first to leave the Nine Elms shops being reproduced.

The points to be noted in connection with this design, for which Mr. Dugald Drummond, M.I.C.E., the company's Locomotive Superintendent, is responsible, are the retention of the cross water-tubes and the employment of a feed-heating apparatus in the tender consisting of 65 heating tubes, each 18 ft. in length by 1¼ in. diameter, furnishing a total heating surface of 375 sq. ft., and maintaining the temperature of the feed-water at 180 degs. Fahr.

The following are the leading dimensions of both engines :—

	L. & S. W. R.	Gt. W. R.
RUNNING GEAR:		
Driving wheels (4), diameter	6 ft. 7 ins.	6 ft. 8½ ins.
Bogie ,, (4), ,,	3 ,, 7 ,,	3 ,, 2 ,,
WEIGHT IN WORKING ORDER:		
Engine, total	53 tons 19 cwts.	55 tons 6 cwts.
Tender, empty	—	17 ,, 9 ,,
,, loaded	44 ,, 17 ,,	36 ,, 15 ,,
On driving wheels	—	34 ,, 6 ,,
,, bogie ,,	—	21 ,, 0 ,,
CYLINDERS:		
Diameter	19 ins.	16 ins.
Stroke	26 ,,	30 ins.
Steam ports	—	31½ ins. circum × 1¾ in. width.
Exhaust	—	31½ ins. circum. × 4½ ins. width.
BOILER: Type	Straight top	Taper pattern.
Barrel length	10 ft. 6 ins.	11 ft. 0 ins.
,, diameter outside smoke-box end	4 ,, 9½ ,,	4 ,, 10½ ,,
Barrel diameter fire-box end	—	5 ,, 6 ,,
FIREBOX: Type	Water-tube	Belpaire.
Length	7 ft 4 ins.	—
Width	4 ,, ½ in.	—
Outside	—	7 ft. 0 ins. × 5 ft. 9 ins. × 4 ft. 0 in.
Inside		6 ft. 2 3-16 ins. × 4 ft. 9 ins. × 3 ft. 2½ ins.
Height		6 ft. 6 7-16 ins. and 5 ft. 0 7-16 in.



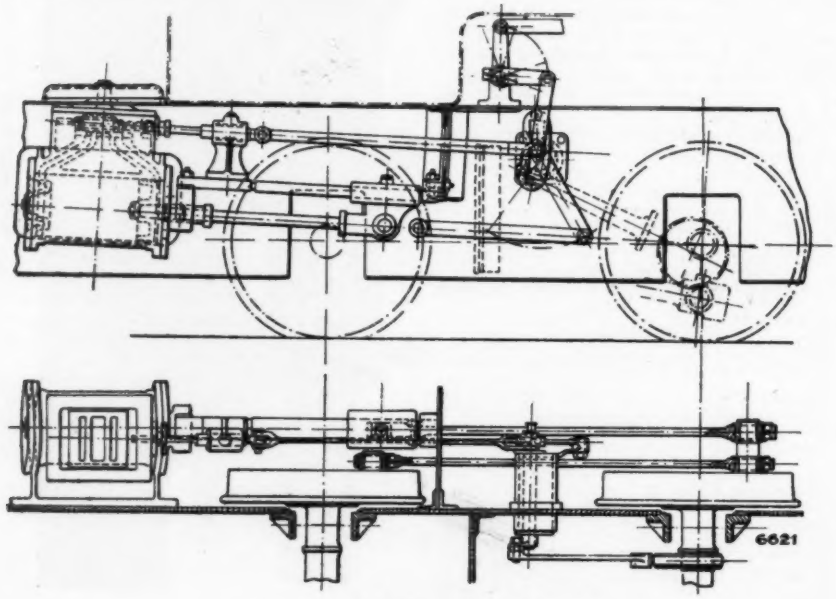
4-4-0 TYPE EXPRESS LOCOMOTIVE, LONDON AND SOUTH-WESTERN RAILWAY.

	L. & S. W. R.	Gt. W. R.
TUBES:		
Smoke, number ...	... 247 ...	350
,, length	10 ft 9⅛ ins.	11 ft. 4 3-16 ins.
Diameter, outside ...	... 1¾ in. ...	1⅝ in.
Cross water, number ..	.. 61 ...	—
,, length ..	...3 ft. 9½ ins....	—
,, diameter	.. 2 ,, 0⅞ ,, ...	—
HEATING SURFACE AND GRATE AREA:		
Heating surface smoke tubes	1,222 sq. ft.	1,689·82 sq. ft.
,, ,, cross water tubes	165 ,, ,, ...	—
,, ,, firebox	... 163 ,, ,, ...	128·3 ,, ,,
,, ,, total	... 1,550 ,, ,, ...	1,818·12 ,, ,,
Grate area	... 24 ,, ,, ...	20·56 ,, ,,
WHEELBASE:		
Driving	... — ...	8 ft. 6 ins.
Truck	... — ...	7 ,, 0 ,,
Engine, total ...	... — ...	24 ,, 0 ,,
Tender	... — ...	15 ,, 0 ,,
Engine and tender ..	.... — ...	48 ,, 3½ ,,
MISCELLANEOUS:		
Capacity of tender tank	... 4,000 gals.	3,000 gals.
Working pressure ...	... 175 lbs. ...	200 lbs.
Tractive force ...	... — ..	21,734 lbs.

The Bagnall-Price Valve Gear.

A NEW and interesting modification of a radial-valve gear has recently been introduced by Messrs. W. G. Bagnall, Ltd., Stafford, constructed from the designs of Messrs. Bagnall & Price, the patentees. The simplicity and ready adjustability of its parts are, perhaps, the most important characteristics of the gear, and render its adoption desirable in circumstances where inexperienced attendants are likely to be employed to look after the engine. The arrangement of the valve chest on the top of the cylinder, moreover, indicates its suitability for narrow-gauge locomotives, where it is often difficult to arrange for the necessary space required by the Stephenson-link gear with its two eccentrics and the valve chest at the side of the cylinder.

The construction and action of the gear may be readily followed by aid of the illustrations, which show it as arranged on a light locomotive. Fixed to the frame between the coupled wheels is a bracket bored out to accommodate a sleeve bush having attached to it, on the outside, a lever which is actuated through a link connecting with the crosshead or to some point near the small end of the connecting rod. The sleeve bush is bored out to form the bearing for a rocking-shaft which derives its motion, by means of a lever, from a single eccentric fixed on the crank-shaft. To the outside end of the rocking-shaft is fixed a radius link connected with the valve spindle by the usual radial rod and die. The oscillation of the radius link set up by the motion of the rocking-shaft imparts the motion necessary for port opening,



DETAILS OF THE BAGNALL-PRICE VALVE GEAR.

that required for lap and lead being obtained independently by the movement of the sleeve bush and lever. The travel of the latter being equal to the stroke of the piston, it will be seen that the lap and lead are determined by the length of the lever and the eccentricity of the rocking-shaft, the complete travel of the valve being thus the result of the combination of both the motions of the sleeve-bush lever and of the rocking-shaft.

The valves are set by fixing the radial rod with its attached die in the centre of the radius link and coupling up with the valve spindle. The engine is then put on each dead centre in turn and the valve adjusted for equal lead on each port. This lead is constant at each end of the stroke for any position of the gear. The eccentric is attached to the axle in the usual way and gives the necessary advance. The gear, which has already been applied to a number of locomotives with very satisfactory results, can, of course, be used in connection with any type of slide-valve engine.

Superheating Trials in Germany.

A RECENT report received from the U.S. Deputy-Consul General at Berlin contains some valuable information relative to further comparative trials of locomotives equipped with Schmidt superheaters. On the distance between Sommerfeld and Berlin an accurate record was kept of the performance of a twin locomotive using superheated steam and of two similar compound locomotives using saturated steam, and it was found that the engine with superheater showed an economy in the amount of coal used amounting to 10·9 per cent. and of 25·8 per cent. in the amount of water used. During these trips the engine with superheater made much better time at starting than the compound engines at the fifteen stations where the train stopped, and it made better time in climbing a considerable ascent near Frankfort-on-the-Oder. Judging by calculations based on the amount of steam produced, it was estimated that the real saving in coal should have been 15·3 per cent. instead of 10·9 per cent., the saving actually attained.

According to the report of J. Obergethmann, professor at Aix-la-Chapelle, locomotives equipped with the most perfected form of superheaters and compound locomotives were tested by the Halle railroad directory, and the average economy in the amount of coal used by engines with superheaters was 11 per cent., and 23 per cent. less water was used. Scientific investigations also showed too great a difference between the economy in water and that of coal. The most exhaustive comparative tests that have been made public were described in a lecture of M. Unger, a railroad inspector, to the Union of German Mechanical Engineers. The management of the Stadtbahn of Berlin, whose lines run through and around the city, caused three engines of types considered best adapted to the service of the railroad, to be tested under conditions as nearly alike as possible. Owing to the fact that engines using superheated steam gather speed much more rapidly at the start than other locomotives, they are especially adapted for urban traffic, and the locomotives with superheaters gave much better results than the two competitors using ordinary steam.

The conclusion reached by M. Unger as a result of the trials made on the Stadtbahn was, that the three-fourths* coupled locomotive with superheater is, owing to its greater efficiency and economy, the only locomotive worthy of consideration for the hauling of heavy trains in interurban traffic. The saving in coal of twin locomotives using superheated steam, over compound locomotives using ordinary steam, varies according to the nature of the service rendered, but the results indicated above would show that 10 to 11 per cent. economy may be at present attained under normal conditions of traffic, and it is likely that this economy may be increased by further improvements in construction.

The fact that the compound engine can be replaced by the simpler twin engine, with increase of power and lower pressures in the boiler, would seem to warrant the satisfaction of the Prussian railroad authorities with the results obtained by them in the use of superheated steam, even if no economy in fuel were attained.

* Four wheels, three coupled.

METALLURGICAL PROGRESS.

Steel.

Recherches Physiques et Physico-Chimiques sur l'Acier au Carbone. The influence of carbon on iron is one of the most fascinating of metallurgical studies, a fact possibly explaining the diverse views held as to the *raison d'être* of this influence. Dr. Benedicks, in the research now before us, has gone most thoroughly into the matter and has rightly worked on the principle of wide correlation. The work is chiefly resolved into an examination of micro-structure, and an excellent series of photo-micrographs testify to the thoroughness of this examination, determinations of density, elasticity, hardness, electrical resistance and magnetic properties. The chief series of steels examined are interesting in that they are an electrical furnace product. Complete analyses are as follows :—

ANALYSES OF GYSINGE STEELS.

No.	C.	Si.	Mn.	P.	S.
1	0·08	0·03	0·13	0·009	0·005
2	0·45	0·65	0·35	0·015	0·02
3	0·55	0·86	0·44	0·014	0·02
4	0·90	0·28	0·41	0·014	0·015
5	1·20	0·30	0·44	0·014	0·01
6	1·35	0·26	0·54	0·014	0·015
7	1·50	0·12	0·29	0·013	0·02
8	1·70	0·03	0·29	0·013	0·03

A series of Open Hearth Fagersta steels, the carbons ascending as follows: 0·16, 0·23, 0·33, 0·38, 0·62 and 0·95 per cent., and a further one of Bessemer steels from Långshyttan, the latter one embracing 25 steels, the carbons gradually rising from 0·10 per cent. to 2·10 per cent. These three series of steels at once show the wide basis of the research, and the choice of commercial products rather than laboratory ones is commendable. A micrographic study of the Gysinge steels shows them to be very homogeneous, but on the whole the structures characterise the carbon content and thermal treatment rather than indicate any special difference due to an electric furnace product. Quite a large portion of the work is devoted to the densities of the steels, the author considering that the most useful results will be obtained by considering not the density but its inverse value or the specific volume. Taking the action of silicon first, many density determinations are given which lead to the conclusion that "the presence of 1 per cent. silicon increases the specific volume of iron by 0·00117 cm³." This result is tested by calculating the specific volume of silicon steels of which the densities have been published. Thus Barrett, Brown and Hadfield give the densities of two such steels, and the author deduces the specific volume as shown in the table :—

Content of Carbon.	Content of Silicon.	Density = D.	$\frac{1}{D}$
0·20	2·87	7·665	0·13047
0·03	0·07	7·842	0·12750
	Difference, 2·80	... ...	0·00297

As the presence of 2·80 per cent. silicon increases the specific volume by 0·00297 cm³, then the presence of 1 per cent. silicon increases the specific volume 0·00106 cm³, a figure which agrees satisfactorily with the author's one of 0·00117. As the density of metallic silicon is 2·39, from the table of Landolt and Börnstein, the specific volume will be 0·418. If in dissolving silicon in iron there were no contractions of specific volume for the two elements, one would observe for the addition of 1 per cent. silicon an increase of 0·00291 in the specific volume of the resultant alloy. As the observed increase has been shown to be 0·00117 there is evidence of a notable contraction. By similar reasoning the influence of other elements is shown, that of manganese having practically no effect. The results are, however, summarised as follows :—

Element.	Increase in Specific Vol. due to 1 per cent. of added element.
Manganese	0·00006
Phosphorus	0·00089
Silicon	0·00117
Carbon	0·0018
Aluminium	0·0025

By reducing the specific volumes to values they would possess if the steels contained no silicon, the following figures are obtained, Δ being the proportional quantity to the content of silicon with which it will be necessary to diminish the specific volume :—

Content of Carbon.	Content of Silicon.	Δ	Specific Volume corrected for the influence of Silicon.
0·08	0·03	0·00003	0·12751
0·45	0·65	0·00076	0·12778
0·55	0·86	0·00101	0·12791
0·90	0·28	0·00033	0·12872
1·07	0·30	0·00035	0·12872
1·14	0·26	0·00030	0·12890
1·35	0·26	0·00030	0·12927

This table shows, after the silicon correction, that the specific volume is a function of the carbon content; and from other results of higher carbon steels, a curve showing a break at 1·3 per cent. carbon has been prepared. This break indicates two carbides; thus, below 1·3 per cent. a carbide Fe_2C, and above 1·3 per cent. a carbide of the composition Fe_3C, this latter carbide having also been indicated by Campbell and Kennedy. The conclusions drawn from the determinations of elasticity may be summarised as follows: For carbon steels the modulus of elasticity decreases as the carbon increases, but at 1·3 per cent. elasticity appears to increase again, further probable confirmation of the carbide Fe_3C. With quenched steels elasticity decreases equally with a rising content of carbon, and is in all cases less than that of similar unquenched steels. Equivalent quantities of carbon, silicon and nickel diminish the modulus of elasticity. In determining hardness, the method of Brinell has been followed, and, as is well known, results obtained by this test show the hardness of annealed steels to increase as the carbon rises. The author, however, makes a strong point of the fact that the hardness does not increase continuously, for at 0·5 per cent. C. there is a sharp increase indicating a constitutional difference between steels less than 0·5 per cent. and those richer in carbon than 0·5 per cent. This break is also noted in the determinations of electric resistance and magnetic properties. From the results of his chemical and physical work, Dr. Carl Benedicks seeks to establish the existence, in steels containing more than 0·5 per cent. carbon, of a new structural element, "ferronite," containing approximately 0·27 per cent. carbon. "Ferronite" is constituted of β iron, as "ferrite" is constituted of α iron. It may be distinguished from ferrite by density, hardness, elongation, as shown by the tensile test, and electric resistance.

Blast Furnace Practice.

Conduit System of Handling Blast Furnace Stock. The conduit system of storage, as described in a recent issue of the *Iron Trade Review*, is designed to provide blast furnace plants with a storage structure possessing the advantages of the bin system, but at a reduced cost of installation and maintenance. The ground serves the purpose of a floor for the bin structure, thereby avoiding the cost of raised bin bottoms. A tunnel runs below this storage floor, and various projecting chutes are thus enabled to discharge material into cars traversing the tunnel. The roof of the conduit slopes towards either side, so that material stored over the tunnel will slide towards the chutes. Charges are weighed and dumped into a pocket fitted with a special door by means of which the skip operator can drop the contents into the furnace skip. Coke is similarly treated, and the skip operator is so placed as to control the weighing of coke, ore, etc., in addition to manipulating the bells and the furnace top and testing the position of the stock in the furnace. Whilst on the subject of blast furnace practice, it is interesting to note the output of iron ore in the United States for the year 1903. As recently published by the Geological Survey, the actual production was 35,019,308 long tons, which is some 534,827 tons below the output of 1902.

Cast-Iron.

Chemical Specifications. In discussing chemical specifications for pig iron Mr. B. F. Fackenthal* presents several interesting sidelights on the influence of remelting in the cupola. For instance, a certain brand of iron, instead of producing the soft castings expected from it, turned out some exceptionally hard ones. Two pigs marked "hard" and "soft" were returned to the makers accompanied by two samples of the unsatisfactory castings. On analysis the samples yielded the following results:—

	Hard pig.	Soft pig.	Casting.	Casting.
Silicon % ...	2·680	2·633	2·327	2·257
Sulphur % ...	0·022	0·023	0·263	0·249

The hard pig was doubtless chilled in the runner, hence presenting a closer grain than the soft one; in all probability the two were from the same cast of furnace metal. As will be noted, the castings contain about 12 times as much sulphur as the original pig, a feature due to bad cupola practice, and one readily explaining the hardness. The author also deals with the loss of silicon on remelting, giving some figures as to the influence of manganese on this loss. The experiments were made in the cupola of a large foundry, and the results are as follows:—

Sample No.	Manganese %	% of total Silicon lost in remelting.
1	0·04	34
2	0·20	23
3	0·43	12
4	0·53	4

* *Transactions*—American Inst. Mining Engineers, and *Engineering News*, Aug. 4, 1904.

Observations on Cast Iron.—Mr. J. E. Johnson* raises the question of the difference between cupola metal and blast furnace or direct metal for castings. In the writer's experience the chief difference is found in the lower average sulphur content of the direct metal. Direct metal is also much hotter than cupola metal, and for equal composition the former yields the softest castings. West has already noted that plates cast from direct metal may be readily planed, whereas machining would have been impossible with cupola metal of similar composition. This softness is stated to be due to the high temperature of the direct metal, and as a confirmatory instance examples are quoted of castings poured direct from a blast furnace making basic iron, the average composition being sulphur 0·03 per cent. and silicon 0·70 per cent. Yet, notwithstanding this low content of silicon, very few of the castings are beyond the machining limit. It may, however, be noted that when the silicon exceeds 0·9 per cent. some difficulty is experienced in preventing holes and soft places due to "kish," which represents an aggregate of particles of graphite so dense as to wholly exclude iron. Kish and graphite are of course identical in properties, the distinction being one of condition only, and lying in the fact that graphite is regularly disseminated through the iron, whilst kish may be regarded as segregated graphite. Kish is formed by molten iron, whilst graphite separates after solidification of the iron. Hence, in order to prevent the formation of kish in direct castings, it is advisable to pour them at a high temperature in order that contact with the mould will cause the metal to pass quickly from the molten to the solid state. In other words, the object sought is to secure conditions in which the region of kish formation may be quickly passed without actual chilling.

The Glazing of Siliceous Pig-iron.—In an examination as to the cause of the glazing of certain kinds of siliceous pig-iron, Mr. O. F. Hudson† comes to the conclusion that the presence of sulphur is largely accountable for the phenomenon. In support of this view the following analyses are of moment :—

No. 2 Foundry.	Siliceous Foundry.	Glazed Iron.	Siliceous iron not glazed.
Good.	Good.	Not satisfactory.	Not satisfactory.
Silicon .. 3·81	4·48	4·01	3·87
Sulphur 0·054	0·048	0·14	0·14

Other analyses are also given showing that glazed iron contains from two to three times the amount of sulphur present in similar varieties of open grained irons, a fact largely accounting for the unsatisfactory properties of the glazed material. From a microscopical examination it is also shown that the graphite in the unglazed pig is larger than that of the glazed one. These observations are also confirmed by sieving tests, in which 73·1 per cent. of the graphite in a No. 1 Northampton iron was too coarse to pass through a 60 sieve, whilst 77·9 per cent. of the graphite from the glazed iron was fine enough to do so, facts which clearly illustrate the difference in size.

Cast-Iron Borings.—The difficulty of successfully utilising cast-iron borings in cupola practice is familiar to all iron founders. Mr. W. G. Scott, in discussing "Scrap-Iron Specifications" before the recent Indianapolis Convention of the American Foundrymen's Association, refers to some methods of utilising this material. When melting borings alone, the oxidation loss will in some cases exceed 30 per cent., whilst under favourable conditions it seldom falls below 10 per cent. A somewhat costly method is to pack the drillings in sheet iron boxes and charge them with the usual pig and scrap. Experiments in briquetting the borings with pitch have not proved a success, owing to the fusibility of the binder. Briquetting with lime, salt, etc. overcomes this difficulty, but introduces others in which the excess of rust due to water is most objectionable. Probably the best method for the ordinary foundry is to pack the borings in wooden boxes, charging them in the cupola with the usual pig and scrap. There is of course a considerable loss, and a noteworthy increase in the content of sulphur. Thus drillings showing 0·085 per cent. sulphur, when melted with a coke containing 0·8 per cent. sulphur, will yield an iron containing about 0·12 per cent. sulphur. The ideal method of handling borings is to melt in an air furnace, in which case comparatively little sulphur is taken up, but the oxidation loss is still great.

Malleable Cast-Iron.

Research Work.—A research on malleable cast iron by Mr. C. O. Bannister forms Appendix II. of the sixth report to the Alloys Research Committee.* The most important conclusions drawn from the work are summarised as follows :—1. A malleable casting always contains amorphous carbon. 2. A casting may lose carbon and still remain fragile, if the remaining carbon is not in the form of graphite or if the initial quantity of graphite is not increased. 3. A casting may become malleable without a sensible loss of part of its total carbon. 4. In general practice the castings lose on the total carbon, and some of the combined carbon is converted into finely divided graphite or temper carbon. 5. The castings generally lose some sulphur, which is found in the hematite ore in such a form as to evolve sulphuretted hydrogen on treatment with acids. 6. As a rule, the other constituents of the castings are not altered to any appreciable amount.

* Atlantic City meeting of American Institute of Mining Engineers, and *Iron Trade Review*. Vol. xxxvii, No. 32.

† Journal of the Society of Chemical Industry. Vol. xxiii, No. 2.

* Inst. Mechanical Engineers, No. 1, 1904.

Loss in Malleable Foundries.—The difference between the year's purchase of metal and the total production of good castings is of interest to all connected with foundry practice. Naturally this interest increases with the value of the metal, and the loss in a brass foundry is of greater moment than that of an iron foundry. In dealing with the loss in malleable iron foundries, Mr. R. F. Flinterman presented to the Indianapolis Convention of the American Foundrymen's Association a series of carefully prepared results. From the many tables given we select the following as typical :—

Product.	Pounds.	Per cent.
Total iron melted	29,920	
Iron recovered from slag ...	159	0·53
Scabs from furnace spout ...	145	0·49
Sprues and floor riddlings ...	12,035	40·22
Total scrap	12,309	41·24
Castings good and bad	16,304	54·49
Total product	28,643	95·73
Loss	1,277	4·27
Slag	1,249	4·17
Iron recovered from slag	159	12·00

Investigating this total loss of 4·27 per cent. it is found that the actual loss on remelting amounts to 1·169 of the charge. The iron in combination with the slag, and therefore unrecoverable, amounts to 0·9 per cent., giving a total of 2·069. This figure taken from the total loss gives a deficiency of 2·2 per cent., which may be accounted for as follows: Oxide and sand adhering to the pig-iron amount to 10 per cent. of the weight. Sand adhering to sprues, etc., has by test been fixed at 7·5 per cent. This sand on the sprues—which are products—to some extent balances the sand and oxide of the pig entering the furnace, yet there are still some 570 lbs. of sand entering the furnace, and which have been weighed as pig-iron. On the charge this is equal to 1·9 per cent., and 1·9 + 2·07 = 3·77 per cent., which is within 0·3 per cent. of the loss as found in the table.

General.

Freezing Point of Antimony-Tin Alloys.—Appendix III* to the sixth report of the Alloys Research Committee gives determinations of a series of freezing points of tin-antimony alloys, by Dr. W. Reinders. The smallest addition of antimony to tin raises the melting point, and a eutectic point lower than that of the melting point of tin has not been observed. The freezing points and points of retardation observed are shown in the following table :—

% Antimony	Freezing Point °C.	Recalescence Points °C.		
100	622	—	—	—
95	612	—	—	—
90	600	439	—	—
85	583	428	—	—
80	564	428	—	—
80	566	433	—	—
70	527	427	—	—
60	484	425	308	237
55	457	428	308	230
52	430	—	—	238
51	435	—	—	246
50	427	—	312	240
50	433	—	307	239
50	425	—	309	240
45	415	—	315	242
40	395	—	306	240
30	358	—	305	243
20	311	—	—	242
10	256	—	—	242
0	232	—	—	—

* Inst. Mechanical Engineers. No. 1, 1904.

Two New Elements.

Dr. Baskerville, whose position as professor of chemistry at a prominent university in the U.S.A., entitles his utterances to every consideration, recently announced that he had discovered what are probably two new elements associated with thorium, both of them radio-active. The two new substances have been christened carolinium and berzelium. Samples of the substances isolated by Professor Baskerville have been sent to Sir William Crookes, who will doubtless confirm or disaffirm the assertion that they are new elements.

The importance of the discovery, says the *Scientific American*, if it should ultimately appear that the two new substances are elements, can hardly be over-estimated; for the number of radio-active substances is now increased to about six. Sir William Ramsay is reported as having every confidence in Dr. Baskerville's announcement.

ABSTRACTS.

Flame Temperature in Internal Combustion Motors. **Dugald Clerk, M.I.C.E.** Had we lived in an atmosphere of much greater density, it is probable that the internal-combustion motor would have developed on very different lines from those actually followed. Assuming an atmosphere of double the present density, say 30 lbs. pressure absolute per sq. in. instead of 15, for given flame temperatures the explosion pressures would have been double, and the non-compression engine of Lenoir would have been much more successful; perhaps, also, the schemes of the earlier English inventors, such as Brown (1826), to produce a gas-engine using vacuum and condenser like the steam-engine, would have been crowned with success. Had we lived in a very dense atmosphere, say of the order of 70 existing atmospheres, there can be little doubt the compression-combustion motor would not have appeared at all, because it would not have been really needed. The explosion pressures to be dealt with would have been so great that the necessity would have arisen for reducing pressure instead of increasing it. This is very well shown by some most interesting explosion experiments recently made by Mr. J. Petavel, of Victoria University, with gas and air mixtures previously compressed over 70 atmospheres and then ignited. These mixtures produced pressures of the order of four to five tons per sq. in. Figs. 1 and 2 are prepared from photographic diagrams which Mr. Petavel has been good enough to send me. They show Mr. Petavel's rising and falling curves with explosive mixtures with about one volume of gas to six volumes of air. It is quite apparent that a gas-engine constructor existing in a world having an atmosphere 70 times as dense as our own would be dealing with explosion pressures of up to five tons per sq. in. at ordinary atmospheric pressure instead of the modest 100 lbs. per sq. in., which is the limit of pressure obtained from ordinary gaseous explosions without compression at present. It is interesting to follow to some extent the effect of such changed conditions as these. It has long been assumed by gas-engine designers that the heat loss to the enclosing walls of an explosion chamber does not increase in proportion to the increase of pressure or density of the gaseous mixture before explosion. No accurate measurements, however, appear to have been made under rigidly determined conditions until some experiments, also by Mr. Petavel, upon the loss of heat to atmospheres of different densities from incandescent metallic wires kept at constant temperatures. Mr. Petavel finds (what gas-engine people long believed) that the loss of heat increases relatively slowly with increase of density. Roughly, his figures appear to prove that, with an atmosphere of 100 density, the loss to the walls increases only six times that of the loss at unit density. This, of course, means that, if a gas-engine could be operated in an atmosphere of double density using exactly the same temperatures, the heat loss would not by any means be doubled. With the same temperatures, therefore, gas-engines under such conditions would be more economical at the high-pressure atmosphere than at the low. Something of this kind has been experienced by gas-engine constructors where engines have been operated at high mountain levels; such engines usually experience not only loss of total power, but also some loss of heat efficiency. In view of certain difficulties which are experienced, especially in large gas-engines of considerable cylinder dimensions, due to impossibility of securing equality of expansion of the metal parts in contact with the hot flame, it is interesting to consider what could be done by reducing cylinder dimensions and increasing

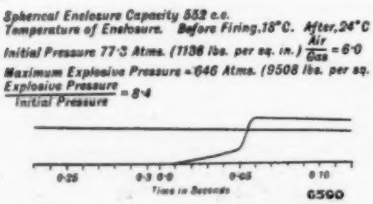

Spherical Enclosure Capacity 552 c.c.
Temperature of Enclosure. Before Firing, 18°C. After, 24°C
Initial Pressure 77·3 Atms. (1136 lbs. per sq. in.) Air/Gas = 6·0
Maximum Explosive Pressure = 646 Atms. (9508 lbs. per sq. in.)
Explosive Pressure / Initial Pressure = 8·4
0·25
0·3 0·0
0·05
0·10
Time in Seconds
6500

FIG. 1.—RISE OF PRESSURE.

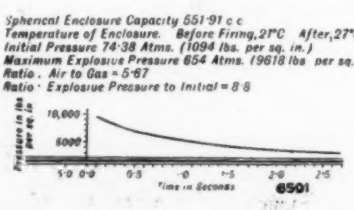


FIG. 2.—FALL OF PRESSURE.

mean pressures within a given cylinder. It becomes interesting, in fact, to consider whether there is no way of working at artificially enhanced atmospheric pressures, because it is obvious that such enhanced atmospheric pressures permit of great flame temperature reductions without requiring reduced maximum or mean pressures. With an atmosphere of double the existing density it is obvious that in a given engine mean pressures may be doubled, or, if desirable, mean pressures may be kept of the same value and flame temperatures reduced—that is, engines may be made much more powerful for a given cylinder diameter, and cylinder losses may be greatly reduced, not only by increased density, but by reduced temperatures capable of giving the desired pressures. In small engines high temperatures may be used with comparative impunity, and, accordingly, we find with both coal-gas and petrol engines flame temperatures in the cylinder as high as 1,800 degs. Cent. to 1,900 degs. Cent. With larger coal-gas engines operating without water-cooled pistons and exhaust valves lower temperatures become imperative, and, accordingly, we find in such engines the maximum temperature reduced to 1,500 degs. Cent., or a little under. Nearly all makers have been forced to recognise the necessity of reducing flame temperature with unwatered pistons and exhaust valves where the cylinders are of dimensions of the order of even 18 ins. diameter. In coal-gas engines, accordingly, the gas and air passages are so set as to produce a sufficiently dilute mixture to prevent the temperature rising unduly. In engines using producer gases of various kinds, the temperature is naturally somewhat lower than with coal-gas, so that special dilution is not so much required. This is also true of the very large engines using blast-furnace gas. In such engines, where the main constituent of the gas used is carbonic oxide, the flame temperature possible is not high, mainly because of the slow-burning nature of the carbonic oxide and the small heat value per cubic foot of the mixture of blast-furnace gas and air. To study the question I have calculated out from a number of recent diagrams the flame temperatures attained in standard engines of various types under the conditions found by the respective makers to give the best economy. Fig. 3 shows diagrams taken from engines operating with coal-gas by well-known makers—Messrs. Crossley, the National Gas Engine Company, and an engine built by Messrs. Fielding and Platt and experimented with by Prof. Burstall. From these diagrams it appears that the maximum temperatures range from 1,500 degs. Cent. to over 1,900 degs. Cent. Fig. 4 shows similar diagrams taken from engines using producer gas obtained from Dowson, Wilson, and Mond producers. Fig. 5 shows a series of diagrams

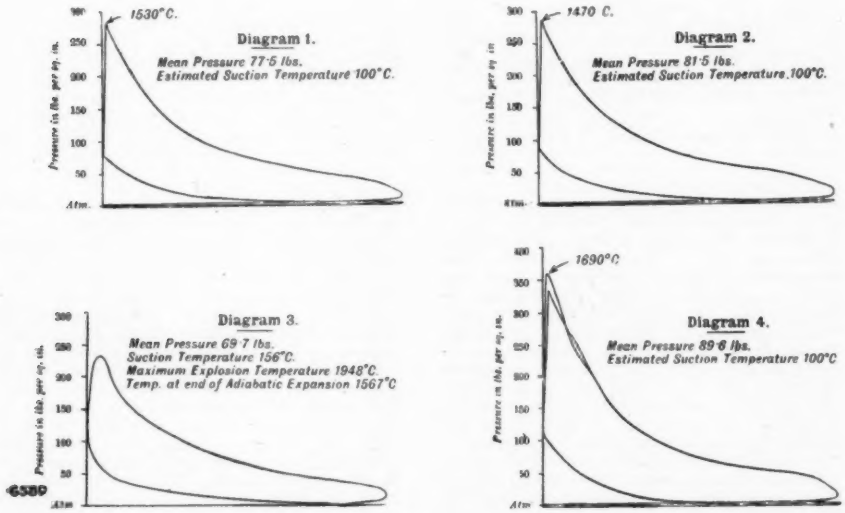


FIG. 3.

Diagrams 1 and 2 from Crossley Two-Cylinder Engine; cylinders, 18½ ins. diameter by 30-in. stroke. Average speed, 172 revolutions per minute. I.h.p. 278. B.h.p. 253. Indicated thermal efficiency, 30·3 per cent. Test made with Manchester Corporation coal gas, 607·5 B.Th.U. per cubic foot, lower heat value. Particulars handed to author by W. J. Crossley, Esq.

Diagram 3 from Prof. Burstall's Second Report to the Inst. M.E.: B trials, test 1. Engine cylinder, 6 ins. diameter by 12-in. stroke. Speed, about 200 revolutions per minute. Indicated thermal efficiency, 19 per cent.

Diagram 4 from National Gas Engine tested by Prof. Robinson. Cylinder, 10 ins. diameter by 18-in. stroke. Average speed, 170·3 revolutions per minute. I.h.p., 26·4. B.h.p., 23. Indicated thermal efficiency, 28·7 per cent.

6589

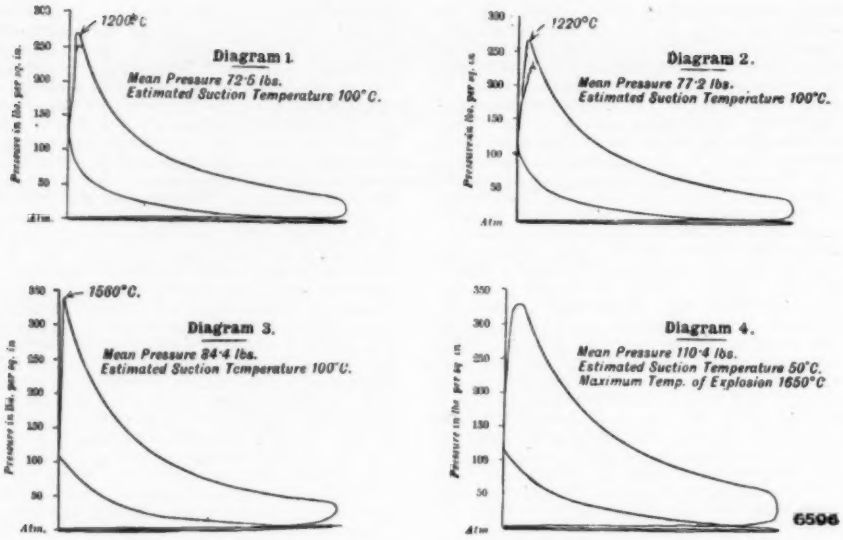


FIG. 4.

Diagram 1 from Stockport Engine, cylinder 20 ins. diameter by 27-in. stroke. Speed, 182 revolutions per minute. I.h.p., 141. At Musker & Co.'s (Ltd.), Liverpool, using Wilson producer gas.

Diagram 2 from Stockport Engine, cylinder 18 ins. diameter by 27-in. stroke. Average speed, 180. I.h.p., 113. At Musker & Co.'s (Ltd.), Liverpool, using Wilson producer gas.

Diagrams 1 and 2 and particulars of test have been supplied to the author by Messrs. J. E. H. Andrews & Co. (Ltd.).

Diagram 3 from National Gas Engine, 40 b.h.p. Speed 170 revolutions per minute, giving 32 b.h.p. at time of test; four explosions and one cut out. Engine at work at Dowson's Works, Basingstoke, with Dowson suction gas plant using anthracite. Diagram taken by the author.

Diagram 4 from Premier Gas Engine at Winnington, two cylinders. Cylinders 28½ ins. by 30-in. stroke. Air scavenging cylinder 43½ ins. diameter. Average speed 128 revolutions per minute. Working with Mond gas. Pistons and exhaust valves watered. Diagram taken from engine by Mr. Humphrey in author's presence.

taken from a very interesting tandem double-cylinder double-acting engine erected by Messrs. Richardsons, Westgarth, & Co., at the works of Messrs. Cochrane & Co., Middlesbrough. The temperatures on one of these diagrams have been taken out. In the producer gas diagrams the temperatures, it will be observed, vary from 1,300 degs. to 1,650 degs. The blast-furnace gas diagram shows a maximum temperature 1,400 degs. Cent. In all the low-temperature diagrams it will be observed that the mean pressure obtained is somewhat low—70 lbs. per sq. in. or under. Two years ago it appeared to me possible to reduce the maximum temperatures to 1,200 degs. Cent., or something near that figure, while maintaining a mean pressure only heretofore possible with high temperatures. My idea was to increase the atmospheric pressure artificially, in order to work under conditions which would permit of any desired mean pressure without requiring a corresponding flame temperature. For this purpose I experimented with two engines —one of 7-in. diameter cylinder by 15-in. stroke, and the other 10-in. cylinder by 18-in. stroke. The 10-in. by 18-in. engine arranged for these experiments is one of the ordinary four-cycle type operated with coal-gas. At the outer end of the stroke the piston over-runs a number of ports placed all round the cylinder, leading into an annular space which is carefully water-jacketed. Two sets of experiments were made with this engine. In one set an additional charge of air was used to increase the pressure within the cylinder after the ordinary charging stroke was complete. The air was compressed by means of a pump driven by belt from the flywheel of the engine. This air was passed into a reservoir, and the reservoir was connected to the annulus in front of the engine cylinder by a pipe. A piston valve was provided operated from the engine-valve shaft, which valve opened at a proper time to fill up the annulus. This annulus was thus filled with air when desired at a determined pressure. The valve actions were so arranged that when the piston over-ran the ports, just completing its charging or suction stroke, air was discharged into the cylinder by way of the ring of ports so as to fill up the cylinder to nearly the pressure in the reservoir, during the time the piston was crossing the ports in completing its out stroke and closing the ports in beginning its return stroke. The suction valve of the engine

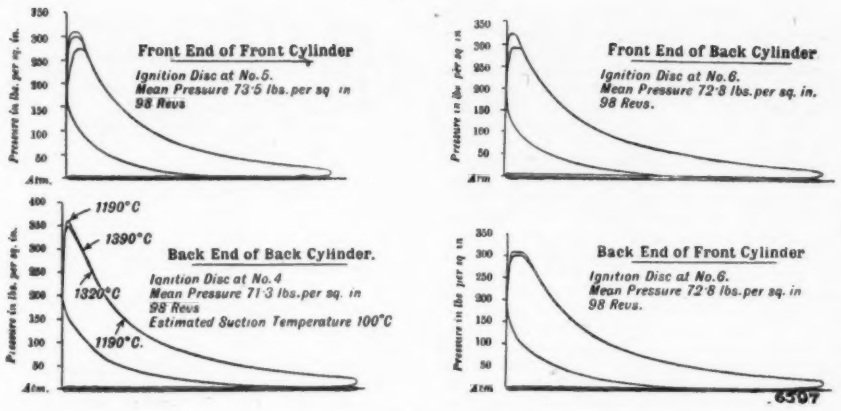


FIG.

] 'Gas Engine, Cochrane ¡No. 250. Cylinders, 29½ ins. diameter by 35½ ins. stroke. Piston rods, 7¼ ins. diameter. Mean m.p. of 4 cards = 72·5 lbs. sq. in. Total i.h.p. at 98 revs = 810. Indicator diagrams taken on July 15, 1904 with temporary load on dynamo. Diagrams handed to uthor by Mr Westgarth.

had to be closed a little earlier than usual to prevent the added charge of air from blowing back into the supply pipe. The exhaust valve, too, in this experiment had to be opened a little earlier to prevent the exhaust gases passing up the overrun ports. With this engine I am able to study the effect of adding an air charge to a charge drawn into the cylinder without altering the amount of gas drawn in. Two diagrams are shown at Fig. 6. One diagram shows the ordinary diagram such as the engine gives without added air. It is not quite as good, however, as the usual diagram obtained from this type and size of engine, as the alterations have slightly impaired the efficiency. The thermal efficiency, however, calculated from the indicator is 27·7 per cent. The usual results obtained from this engine show a thermal efficiency of 28·7 per cent. The other diagram with added air shows clearly the increase of efficiency due to dropping the temperature. The addition of air here increases the thermal efficiency of 27·7 to 34·4, while the temperature falls from about 1,700 degs. to 1,200 degs. The real improvement effected by the addition of air is better taken as compared with 28·7, the ordinary efficiency, rather than 27·7. A substantial improvement, however, is here shown—about 20 per cent. on the diagram. In this particular experiment, the brake power with added air is, of course, considerably increased; but as the compressing pump was attached in an entirely experimental way, the results of the brake tests made during the experiments are not of much interest. Another set of experiments were made on this engine, in which the additional atmosphere was supplied without a separate pump by means of the exhaust gases passing from the engine itself. In this experiment the same engine was used with the annulus and ring of ports at the front end of the cylinder, but here the piston-valve was so operated in conjunction with the exhaust-valve that the exhaust gases under pressure from the cylinder were allowed to pass through the front ports by way of a cooled pipe to a reservoir, and the opening of the ordinary exhaust-valve was adjusted to discharge into the reservoir exactly the amount of exhaust required

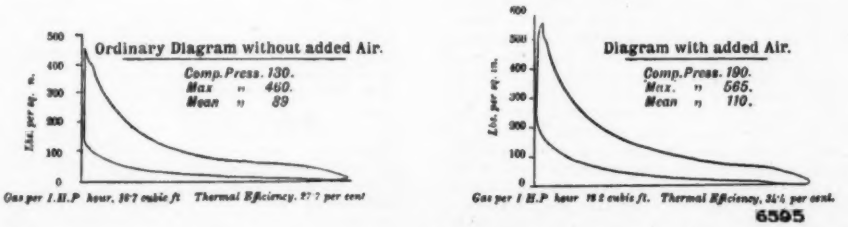

Ordinary Diagram without added Air.
Comp. Press. 130.
Max " 460.
Mean " 89
Lbs. per sq. in.
Gas per I.H.P hour. 18·7 cubic ft. Thermal Efficiency. 27·7 per cent
Diagram with added Air.
Comp. Press. 190.
Max. " 565.
Mean " 110.
Gas per I H.P hour 15·2 cubic ft. Thermal Efficiency, 34·4 per cent.
6505

FIG. 6.

Average diagrams from 10-in. by 18-in. National Engine.

to give the desired exhaust pressure. At the end of the suction stroke, before the out-end ports are over-run, the piston-valve opens to the cold end of the reservoir, and shuts off communication to the hot pipe. Cooled exhaust products thus fill the ring, and, discharging into the cylinder, bring the pressure up to the artificial atmosphere desired. Fig. 7 shows three diagrams with particulars marked under them taken from this engine under these circumstances. The upper diagram is the power diagram; the lower two diagrams show on scales of one-fortieth and of one-tenth the effect of adding the exhaust charge under pressure. In this case, comparing the best results obtained with the engine by Prof. Robinson in his test found at p. 254 of his book, we find an increase of 5 b.h.p., an improvement in indicated efficiency, increasing the indicated thermal efficiency from 28·7 to 32·5 per cent., and an improvement in the brake efficiency from 25 to 27·5 per cent. This improvement is obtained entirely by adding exhaust products under pressure to increase the weight of charge present, to increase the pressure before compression, and to diminish the flame temperature. This method of exhaust super-compression has the great advantage over air super-compression that no additional pumping is required. There are certain advantages, however, to be obtained from the use of air super-compression, notwithstanding the addition of a pump, and these advantages have induced the National Gas Engine Company to build an engine (shown at Fig. 9) to carry out the fundamental idea of reducing flame temperatures while increasing mean pressures. This engine is intended to indicate 300 h.p. when working with producer gas of about 150 British thermal units per cub. foot. The idea is to keep up mean pressures while keeping down flame temperatures in order to avoid the well-known liability of heavily loaded gas engines to overheating and pre-ignition. The engine is now at work with a weaker gas, and diagrams are shown at Fig. 8. In this engine the back end of the cylinder is arranged as a four-cycle motor of normal type; the front end is arranged as an air-pump, and is closed with cylinder cover, through which a piston-rod passes from a cross-head guide of usual construction. One air-valve is operated at the pump end from the cam shaft. On one back stroke a charge of air is taken into the cylinder, the valve is closed, and on the out stroke this air charge is compressed into a reservoir forming the clearance space, between the piston and the cylinder head. Ports over-run by the piston communicate with this clearance space, which is well water-jacketed, and the pressure causes the air to flow into the cylinder when the charging stroke is nearly complete. In this way the pressure of the charge is raised to about 7 lbs. per sq. in. The pressure in the front reservoir is raised to about 16 lbs. per sq. in., as is shown upon the diagram, but the fall is only sufficient to raise the pressure within the cylinder to about 7 lbs. above atmosphere. The reservoir still contains some air at a little above 7 lbs. pressure, and this air is used on the next exhausting stroke to act as a scavenging air charge to displace the exhaust

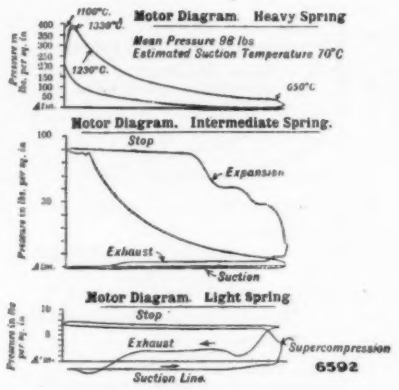


FIG. 7.

National Gas Engine altered for exhaust super-compression experiments. Cylinder 10 ins. diameter by 18-in. stroke. Speed 180 revolutions per minute. B.h.p. 28. Indicated thermal efficiency, 32·5 per cent. Brake thermal efficiency 27·5 per cent. Test made by author with Ashton Gas; 566 B.Th.U. at 82 degs. Fahr. gas temperature, lower value. A later test with slightly diminished combustion space gives 27·2 b.h.p. Indicated thermal efficiency 34 per cent. Brake thermal efficiency, 29 per cent.

products from the cylinder and secure that no exhaust remains to form part of the further charge. The engine is thus not only a super-compression engine, but it is a scavenging engine. The pump side is arranged to draw air in on one stroke only—that is, the valve only opens once in two revolutions. One air charge is sufficient both for the purpose of super-compression and scavenging.

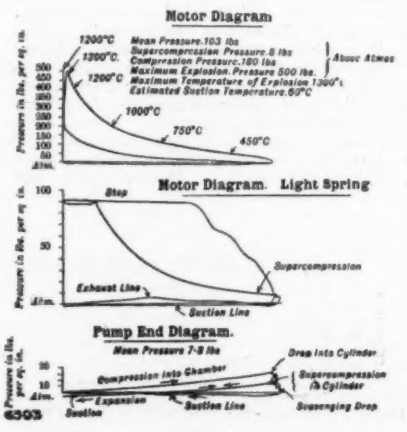


FIG. 8.

Diagrams taken from 21 ins. by 34 ins. National Engine illustrated at Fig. 9. Revolutions at test 160 per minute.

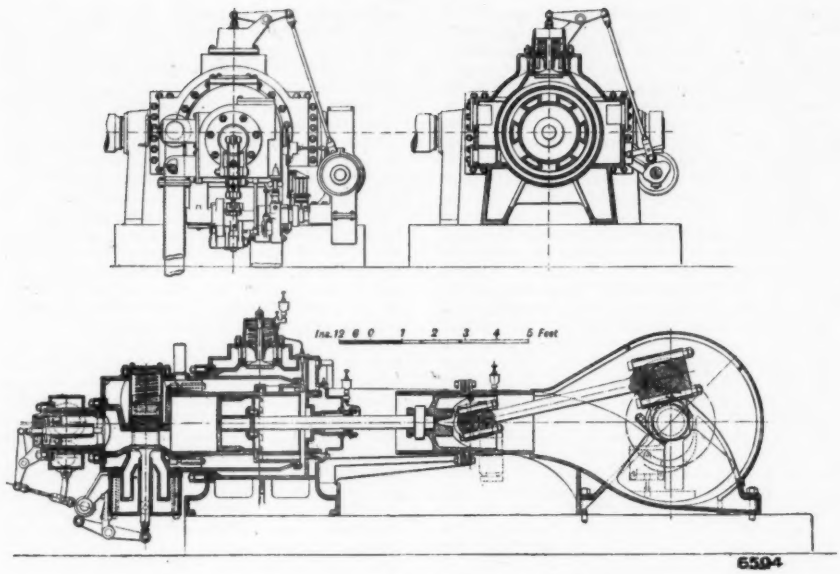


FIG. 9.—DETAILS OF 300-B.H.P. NATIONAL GAS ENGINE.

Calculation from the diagrams proves clearly that a high mean pressure of over 100 lbs. per sq. in. is obtained with the very low maximum temperature of 1,200 deg. Cent. The effect of this reduction of temperature in the smooth working of the engine is most remarkable. The tendency to pre-ignition or overheating is found to be entirely absent. Notwithstanding the fact that no watered piston is employed, the engine runs with perfect certainty at full load, with consecutive ignitions, at 160 revolutions per minute. So far as my experience goes, no engine of these dimensions without a watered piston could run at an average pressure of over 100 lbs. per sq. in. without difficulty due to pre-ignitions. So far, my attempt to use higher atmospheric pressures has succeeded. It has allowed increased load for a given cylinder and permitted consecutive ignitions at full load and speed without requiring any water cooling of the piston. It appears probable that temperatures may be still further reduced with advantage, especially in operating large gas-engines. I need not inform the body of engineers before me that the difficulties with which the large gas-engine is at present struggling, are in main due to the high temperatures of the flame in the interior of the cylinder. So long as high-temperature flames are used within cylinders of relatively small dimensions, the difficulties due to unequal expansion of parts do not appear. The steam engineer is well aware of the care which has to be exercised in using large steam-cylinders in such a way as to avoid cracking, and he can quite well imagine that the difficulties of allowing for free expansion in a gas-engine cylinder are much more serious than his own when he considers the relatively low temperature of his steam. Even with superheated steam, 300 degs. Cent. is a fairly high temperature, while in existing gas-engines of either large or small types it may be taken that the lower limit of maximum temperature at present is nearly 1,400 degs. Cent. The water-jacketing of a moving piston is an admirable expedient most carefully and ably carried out by many Continental and English engineers; but it is an expedient which has never satisfied me, and is, I believe, regarded with distrust by a considerable number of English engineers. In my view many of the troubles which have been experienced with large gas-engines—cracking pistons, back covers, and the like—are due to the difficulties introduced of getting rid of very large heat flow through cylinder and piston walls, and it appears to me desirable, if possible, to reduce this flow to the lowest point consistent with maintaining the economy of the engines. In doing this, of course, it will not do to reduce the mean pressures of the engines. Large gas-engines are at present undesirably heavy for the power as compared with steam-engines, and it will not do to increase the weight in any way by reducing the temperatures. This plan of artificially raising atmospheric pressure, either by the addition of air under pressure or by the addition of cooled exhaust gases under pressure, appears to me to furnish a very promising solution of the problem In gas-engines operated with

producer gas or blast-furnace gas the question of maximum possible economy is not at present a pressing one. The thermo-dynamic efficiency of all gas-engines is now so much greater than any heat efficiency attained in steam-engines that we can well afford to reduce economy, if need be, in order to make more certain of good practical results—that is, to make more certain of low cost for upkeep and repairs. In my view it would pay in large gas-engines even to reduce fuel economy if by so doing entire immunity from breakdown was secured. So far the best means of limiting temperature in a simple way appears to be found in the addition of cooled exhaust gases to the charge before compression; and this method, although reducing flame temperature, has actually increased the efficiency instead of diminishing it. This is quite evident from the figures shown with reference to air and exhaust super-compression diagrams found at Figs. 6 and 7. The results obtained with the 10-in. by 18-in. engine are, so far as I am aware, the best heat efficiencies ever obtained from a gas-engine of the dimensions. It will be noted that the exhaust super-compression indicated efficiency is 32½ per cent., while the air super-compression indicated efficiency is 34·4 per cent. The exhaust super-compression thus appears to give slightly lower results than the air super-compression in the same engine. Theoretically, under equal conditions, the efficiencies should be the same for either air or exhaust gas additions. No doubt the cause of difference is due to a somewhat smaller clearance space which was used in the engine while the air experiments were in progress. It would have been interesting to compare the heat efficiency of the large air super-compression engine with the smaller one, but unfortunately I have not been able yet to instal apparatus for making accurate measurements of the producer gas supplied to this large engine. The results obtained I will have pleasure in publishing later. In bringing forward this question of flame temperature in gas-engines, both large and small, I must not be understood to depreciate in any way the efforts of those able Continental and English engineers who have made so brilliant an advance in the application of the large gas-engines to producers and blast-furnace gas within the last few years. Nothing is to be gained, however, by over-estimating our present position either with regard to large or small gas-engines. With small and moderate engines, no doubt, it may be considered with truth that all the problems have been solved, and that in these engines, not only on the point of heat efficiency, but also in all points of reliability and low cost of repairs, the gas engine more than holds its own with the steam engine. This cannot yet be said, however, of the really large gas engine. At present these engines are in a state of somewhat rapid change, and the types upon the market are so numerous and varied that they are engaged in a struggle of which the fittest will survive. This question of flame temperature, however, affects them all; and much will be gained if engineers will frankly recognise flame temperature as a matter to be dealt with in itself, instead of merely providing palliatives to neutralise the effects of high flame temperatures when generated. The advance in the knowledge of the theory of internal combustion motors has made it quite clear that so long as flame temperatures are higher than temperature of adiabatic compression, so long will the full thermo-dynamic efficiency be attained for a given compression. This fact, however, barely requires re-statement; it is so largely recognised by all gas engineers. In Britain at present we are fortunate in having before us examples of all the leading internal-combustion motors of the world, large or small. British makers are now occupied in building, among large gas engines, those of the Cockerill, Ochoelhauser, Koerting and Westinghouse types; while other English firms, such as Crossley Bros., the National Company, and the Premier Company, are producing large gas engines of British invention on British lines. Indeed, some of the Continental engines may also be said to be operated on British lines, because both the Koerting and the Ochoelhauser engines are really modifications of the Clerk cycle invented and operated in this country over 20 years ago. From this it will be seen that British makers are no longer neglecting—if they can be said to have ever neglected—the large gas engine problem. So far as small and moderate gas engines are concerned, British engineers have a very long lead. From information supplied me by many English firms, I estimate that there have been manufactured and sold from Britain alone some 100,000 stationary gas engines, the average power being something like 20 h.p. The present output of gas engines in Britain is very large. It at present amounts to at least 200 engines per week. This includes stationary gas and oil motors, but takes no account of petrol motors for cars. So far as these engines are concerned, the British position could not be improved upon. In the large gas engines, too, the problem is being seriously attacked. I had the pleasure of visiting the works of Messrs. Richardsons, Westgarth & Co., Ltd., a couple of weeks ago, and inspecting at Middlesbrough and Leeds a number of large engines built by them. They show a very interesting installation of seven Cockerill engines coupled to blowing cylinders in one engine-house. These engines are rated at 600 h.p. each, so that this one engine house contains 4,200 h.p. of gas power for using blast-furnace gas. The engine installation is practically complete, and will be in operation when the scrubbing plant for the gas is finished fitting up. Messrs. Richardsons, Westgarth & Co. also showed me a tandem-cylinder double-acting gas engine of very interesting construction, from which the diagrams shown at Fig. 5 have been taken. This engine was shown to me in operation at the works of Messrs. Cochrane, of Middlesbrough, driving a dynamo. It worked with all the steadiness of a steam engine, and the governing was effected by varying the gas admission, keeping compression constant, so that two impulses were given to the crank at every revolution under all circumstances, light and loaded. This is a most interesting engine, which promises very well. I also inspected two single-cylinder single-acting Cockerill engines of 250 h.p.

at the pits of the Yorkshire Coal & Iron Company, near Leeds, where they were driven by coke-oven gas, also an interesting installation.* This question of flame temperature appears to me, perhaps, the most important and fundamental at present before engineers engaged in the design of these internal-combustion motors. It is fitting that this branch of the subject should be considered before the British Association, and assistance is particularly desirable from physicists who have interested themselves in temperature measurements, especially high-temperature measurements. The determination of these flame temperatures is one of great difficulty, and the data available are very incomplete. Certain assumptions have to be made, for example, as to the temperature of the total charge at the moment of filling the cylinder before compression begins. The only serious attempt to determine this charge temperature has been made by Prof. Burstall in the very able experiments conducted by him for the Gas-Engine Research Committee of the Institution of Mechanical Engineers. In arriving at the flame-temperature numbers given in this paper, I have made free use of Prof. Burstall's results to enable me to assume some reasonable temperature for the "suction temperature," as Professor Burstall calls it. The whole of this subject requires investigation, and new methods require to be discovered to enable the determination of the suction temperatures to be easily made for every experiment. I am glad to say that a committee of the Institution of Civil Engineers has been formed to attack the whole question of the thermo-dynamic standard for these engines; and, among other points, I hope that this point of flame temperature and its determination will be duly considered. There can be no doubt that in these times, when internal-combustion motors are being applied to every purpose of motive power both on land and sea, the scientific problems—which, after all, are fundamental and necessary to rapid progress—require much more serious consideration than has been yet given them.—*Paper read before Section G of the British Association Cambridge Meeting, Aug. 19, 1904.*

A Universal Testing Machine of 300 tons for Full-sized Structural Members. **Mr. J. H. Wicksteed, Pres. Inst. M.E.** The direction in which the machine about to be described has carried testing further than any previous machine is in its ability to test the strength of full-sized members of structures. It will test a strut 88 ft. long by 3 ft. 3 ins. by 3 ft. 3 ins., or a chain-cable 13 fathoms long of 4¾-in. diameter iron, and it will test a beam 3 ft. 3 ins. broad, 6 ft. 8 ins. deep, by 20 ft. between supports. It has also carried shearing tests further than hitherto. It will test in single shear a bar 8 ins. wide by 2¼ ins. thick. Machines of comparatively small dimensions suffice for testing specimens of the material of which struts, links, girders, and arches are made, but when you wish to test the struts, etc., themselves, which form bridge members, or members of any construction, the machine must be large and powerful; and to do this work economically the machine must be so designed that testing long or short pieces in any of the different senses can be accomplished without any change of appliances which involves labour and delay. The very reason for testing by machinery is to save time and labour and expense. Think what the expense would be to load a girder with 300 tons of deadweight! The weights themselves, and supports for the girder, would cost about £2,400. The loading and unloading of the weights would make each experiment cost a hundred times as much as if it were made on the machine to be described. A testing machine measures the load which is applied to a specimen instead of actually loading the specimen with dead-weights, and in proportion as the loads are large, the saving between direct loading and measuring the load by a machine becomes large also. The most primitive form of machine is to have the specimen anchored to a foundation at one end and pulled at the other end by the short end of a lever with scale pan for weights at its long end, but there is as much difference in convenience and economy between such a machine and the most highly developed form of machine as there was between the use of a lever and the simple use of direct loads. The next step in the development of testing machines was to apply tractive force to the end of the specimen, which had previously been anchored, and measure this tractive force by lever and scale pan as before. The earliest machines of this kind were made after the introduction of chain cables for ships, which took place in 1813, and when these had become largely adopted in place of hemp cables by the Admiralty a machine was made for the Royal Woolwich Dockyard by Bramah of Pimlico. The machine had a hydraulic cylinder at one end to put the pull on to the chain, and levers with small weights at the other end to measure the amount of the pull. It was on this machine that Prof. Barlow made his experiments on the strength of materials, but neither the machine of 1813 nor the machine of 1832 was adapted for testing struts, and for anything else but chains they must have been extremely inconvenient. The introduction of steel for shipbuilding in 1875 led to a very large amount of testing plate strips in machines of about 50 tons power. These machines have been made so convenient for the special purpose, that a specimen of steel plate can be accurately tested for strength and extension every minute; in other words, sixty tests an hour is not unusually quick. Side by side with this large expansion in testing specimens of material which was caused by the introduction of steel for shipbuilding and for boilers, there has been a slower expansion in the direction of testing actual structures. As has been said, the machine of 1813 was for testing actual chain cables. Later on a demand arose for testing other structures such as struts, and in the same year that marked the increase of testing of plate strips the importance of putting down more machines for testing structures was taken up in the U.S.A., where their methods of constructing

* C., page 278.

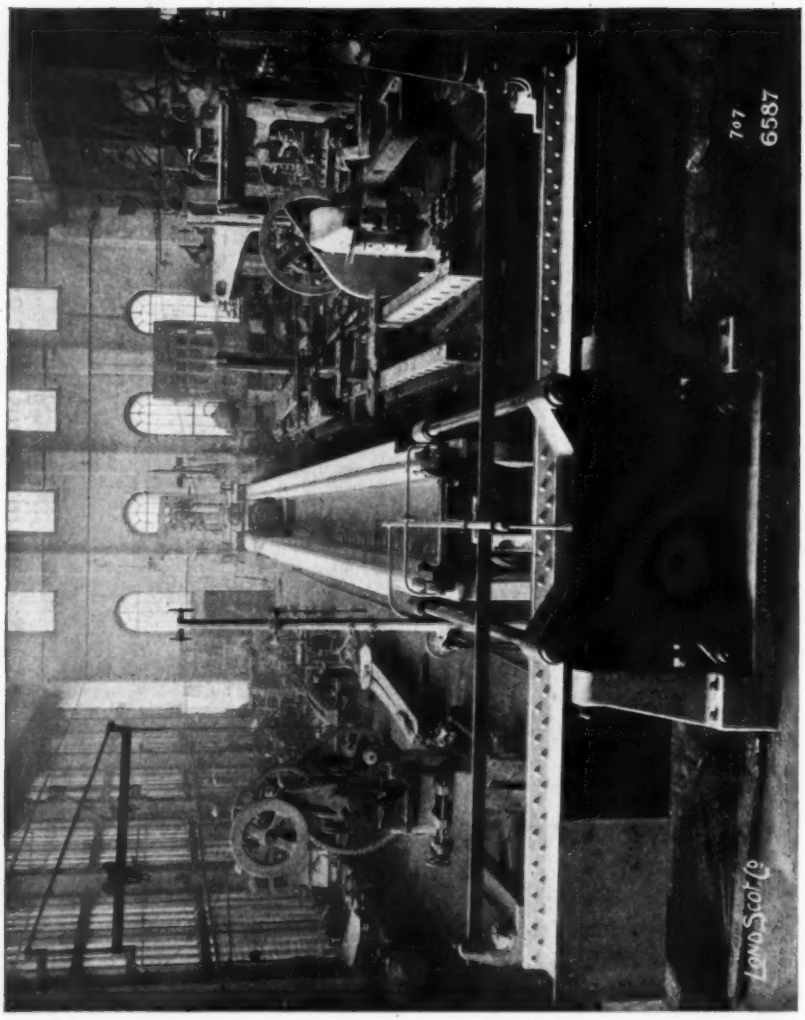


FIG. 1.—THE 300-TON TESTING MACHINE IN MESSRS. BUCKTON AND CO.'S WORKS.

bridge girders particularly demanded testing the actual tension and compression members; this led to the United States Government putting down the celebrated machine at Watertown Arsenal. The machines for testing both in tension and compression to any large scale have all been made within the last half-century, and in all these machines an attempt has been made to utilise them not only for sizable members of structures, but also for large and small specimens of material.

The arrangement of a machine for measuring either in compression or tension, and at the same time for lending itself conveniently to deal with long or short pieces, is not easy of accomplishment, and has been attempted with varying success. The development of these universal machines, may be traced as follows:—In 1852, Ludwig Werder, of Nürnberg, made a machine adapted for both tension and compression. In 1866 Mr. David Kirkaldy opened his machine, which would

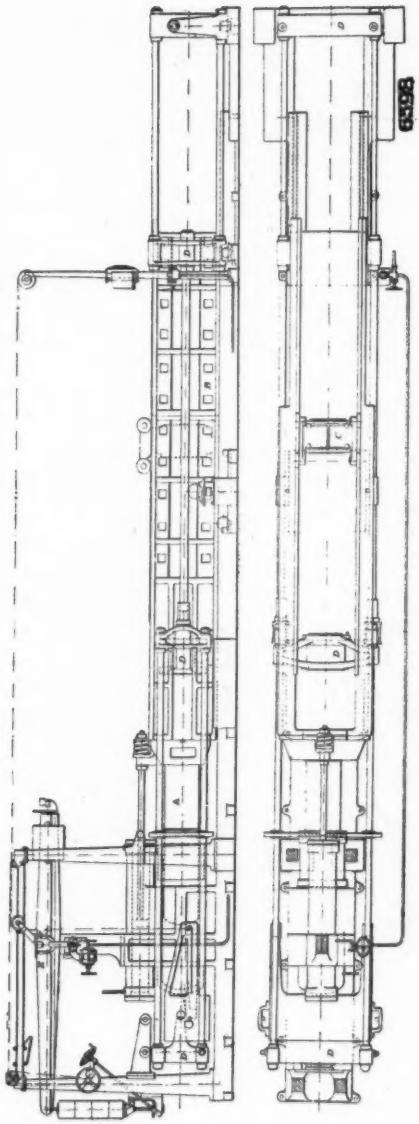


FIG. 2.—300-TON TESTING MACHINE: DIAGRAM SHOWING THE WORKING PARTS.

test both in tension, compression, and deflection. In this machine he can test a cast-iron column 21 ft. 6 ins. long by 2 ft. by 2 ft. 8 ins. to destruction with a load of 270 tons. In 1879 a machine, built by Mr. A. H. Emery, was started at Watertown Arsenal, U.S.A., which would test in all the senses of Kirkaldy's to about the same loads, and which would take in columns 30 ft. long by 2 ft. 6 ins. by 2 ft. 6 ins. The nominal power of this machine is 357 imperial tons. At Charlottenburg, a machine was put down in 1894 to test up to 492 imperial tons, and to take in columns 49 ft. long by 2 ft. 7 ins. by 2 ft. 7 ins. In review of these machines it may be said that in the Werder machine the balancing levers are carried on a hydraulic ram, and pull the straining cross-head with them. The rest of the machine consists of an inert bed extending in the opposite direction to the ram, and on this bed short lengths of cast-iron pieces are placed so as to vary the distance of a stationary cross-head to suit long or short tension pieces. For compression, the cross-head carried by the balance is altered in distance by links to compress longer or shorter pieces between itself and the butt end of the hydraulic cylinder. In the Kirkaldy machine the hydraulic cylinder is in the same position as Werder's, with the ram working outwards from the end of the bed, but the balancing levers are at the other end of the inert bed. The ram pulls the straining cross-head through four screws, and the cross-heads can therefore be adjusted to any required distance from the balancing cross-head. For compression tests, a set of eye-bars are required to carry a compression platen from the balancing cross-head to the side of the straining cross-head, which is next to the hydraulic cylinder. In the Emery machine the difficulty of adding or removing parts to change the machine between tension and compression is got rid of by having the hydraulic cylinder double-acting, so that it will either push or pull on to the balance, and by making the balance so that it can either be pulled against a chamber containing fluid, which delivers the pull to the scale beams, or the chamber can be pushed against the balance, when it equally delivers the pressure to the scale beams. The difficulty of coupling the machine to long or short pieces is dealt with by moving the hydraulic cylinder, with its double-acting piston and straining head complete, to the desired distance away from the balance. In the Hoppe machine at Charlottenburg, instead of having a double-acting piston like Emery, the hydraulic cylinder can be locked to the bed so that the ram goes forward, or the ram can be locked to the bed so that the cylinder goes backward. The straining cylinder will therefore either exert a push or a pull, and the balance is made so that it will deliver either a push or a pull to the weighing levers by arranging for a push to act upon the short arms of two elbow levers, and the pull to act upon the elbows of the levers, while the short arm forms the fulcrum. In other words, the elbow levers, when balancing tension, act as levers of the second order, and when balancing compression as levers of the first order. The difficulty of coupling to long or short pieces is dealt with as in the Emery machine, by

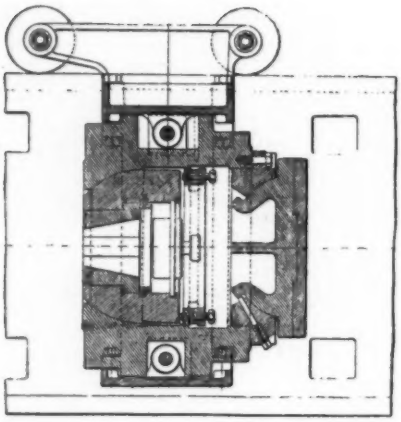


FIG. 3.—THE STRAINING CROSS-HEAD.

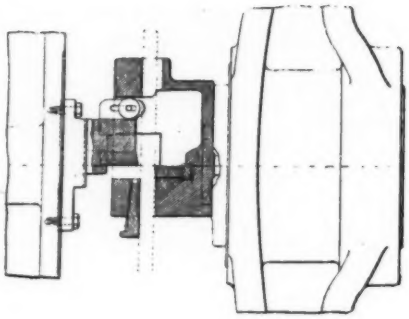


FIG. 4.—SHEARING APPARATUS.

traversing the hydraulic cylinder upon the bed nearer or further from the weigh-bridge. The author has succeeded in making a machine which requires no parts to be added or removed to prepare it for its function of testing in compression or in tension, nor to prepare it for taking long or short pieces, and this is accomplished with a single-acting ram, and with a balance always pressing in the same direction upon the short end of a lever of the first order. In 1904 the French Government opened at the Conservatoire Nationale des Arts et Métiers the machine to be described, which will test up to loads of 300 tons in compression, tension, deflection, and shearing. It will take in columns 88 ft. long by 3 ft. 3 ins. by 3 ft. 3 ins., and tension members of the same length and diameter. This machine was made by the author's firm—Messrs. Buckton & Co., of Leeds. Fig. 1 is a view of the machine, taken from a photograph, as it stood in the makers' works. In common with every testing machine, this machine comprises three principal parts—the apparatus which applies the load, the apparatus which measures it, and the frame or bed. But there are two leading advantages in this design which make it differ from all others. First, the frame or bed, instead of being fixed as in ordinary machines, is movable; secondly, the weighing levers, contrary to the general arrangement of machines with fixed beds, are at the same end as the straining cylinder, and they are mounted on this stationary cylinder instead of being carried on the moving ram as in the Werder machine. It is this combination which gives the machine the facility which it possesses for testing a great variety of sizes, and for testing either in compression or tension without rearranging the machine. Fig. 2 p. 307, is a diagram showing the working parts, but does not show the full length of the machine, 60 ft. of the length of the sliding-trough is omitted so as to bring both ends of the machine into a compassable diagram. The length of trough which is omitted is a simple continuation of the length that is shown. *A* is the hydraulic ram, *B* the sliding-trough or straining frame, *C* the straining cross-head, and *D D D* the balancing system which floats upon rollers, and nowhere touches the sliding-trough. The balance delivers the load to the steelyard *E*. The beauty in the design of this machine, which gives it its great convenience, is that the hydraulic ram moves a long frame which is the whole length of the longest specimen. This straining frame is both surrounded and traversed by a balancing frame, the result is that the straining cross-head can push on to one part of the balancing frame and pull on to another part, and the straining cross-head can itself be run along the straining frame into a position for pulling or pushing either long or short pieces. Fig. 3 gives a view of the straining-head containing the clip-boxes, which are spherical and are shown in detail on the diagram. One of the compression platens also has a spherical seat, so that it can be adjusted to suit the end of a column which is not quite parallel on the two ends. This is also shown on the figure. Fig. 4 shows a view of the shearing apparatus, which is designed for single shear. The machine is fitted with a complete apparatus for making autographic records, of which the following will serve as illustrations:—Fig. 5 gives particulars of a test with a Great Northern connecting-rod, which carried a thrust of 84 tons between parallel pins which supported it on plummer blocks. Fig. 6, of a riveted joint with nine 1-in. diameter rivets, broken with a pull of 214 tons. Fig. 7, some rolled joists tested as struts. It will be noticed that test No. IV. made as a strut with plates riveted squarely to the ends withstood double the load that No. II. of the same size joist, but with round ends, withstood. Fig. 8 shows diagrams

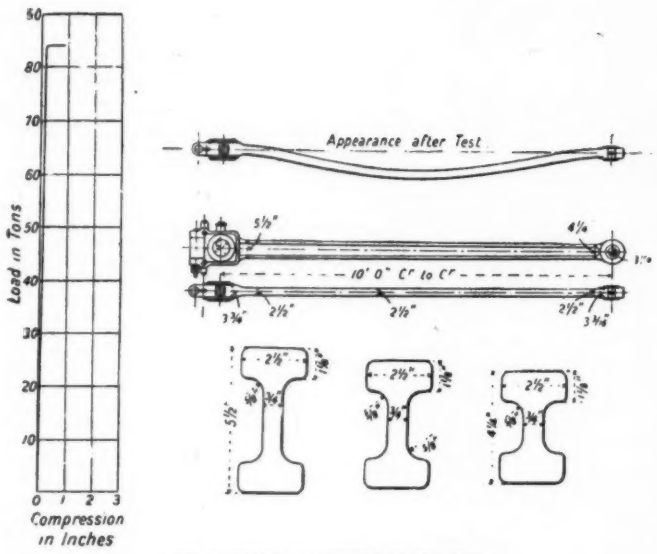


FIG. 5.—DETAILS OF CONNECTING-ROD TEST.

of shearing experiments on bars rising by ½ in. in thickness from ½ in. to 2½ ins. It is noticeable that the 2½-in. thick bar did not take five times the load, nor the 2-in. thick bar four times the load that was required to shear the ½-in. thick bar. A very complete article on this machine has been given by M. Breuil in *Le Génie Civil*, and in this article he says :—"It is more and more necessary to differentiate between the testing of parts themselves and testing specimens of the material of which the parts are made. Machines of small power which suffice for the latter are of no value for the former purpose." Speaking of the watertightness of the hydraulic ram, he says : "This we have verified by putting a tension of 32 tons upon a bar of steel one evening, and finding the next morning that it still had a tension of 30 tons. The leaks past the piston were therefore imperceptible, and the machine can without difficulty be used for delicate measures of elasticity." Alluding to the movable straining head, he says :—"Thus to pass from one kind of test to another there is no need, as in ordinary machines, to employ long coupling-rods, which, with a machine of this size would be extremely cumbersome ; it suffices merely to run the moving cross-head to the required position which, as it is mounted on wheels, can be easily done by a single man." Locking the moving cross-head to the sliding bed is very quickly done ; it requires only about a minute. "All the motions of the sliding-bed, as well as the adjustment of the poise weight on the steelyard are controlled without difficulty by a single operator on the platform—an economy of labour which is worthy of remark." Alluding to the diagram apparatus, he says : "The interest attaching to the preservation of an autographic record of tests is at the present time becoming more and more appreciated. We have not failed to conform to this requirement, and, whatever may be the kind of test carried out, the machine is capable of tracing the complete diagram. The loads are recorded upon a large drum by a vertical displacement of a pen by means of a wire which moves at the same time as the travelling poise weight, and an amount proportional to the displacement of this latter. By means of a train of change wheels actuated by the hand wheel controlling the traverse of the

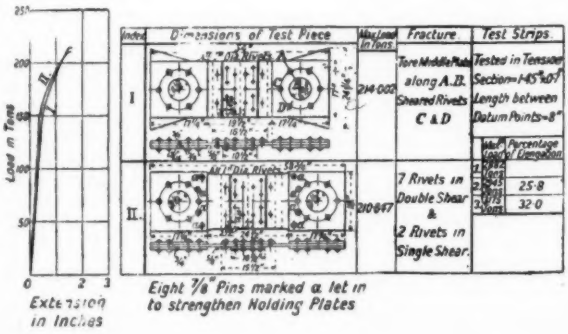
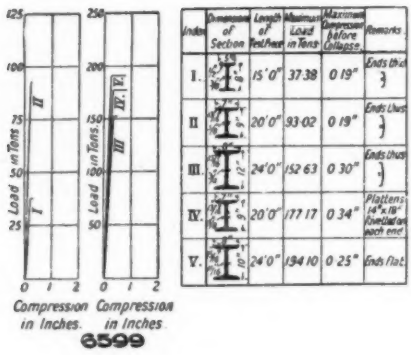

Load in Tons
Extension in Inches
Dimensions of Test Piece
Fracture
Test Strips
Tore Middle Rule along A.B. Sheared Rivets C & D
Tested in Tension
Section=1·45"×0·7"
Length between Datum Points=8"
Percentage Elongation
25·8
32·0
7 Rivets in Double Shear & 2 Rivets in Single Shear.
Eight ⅞" Pins marked a let in to strengthen Holding Plates

FIG. 6.—DETAILS OF TEST ON A RIVETED JOINT



Index	Dimensions of Section	Length of Test Piece	Maximum Load in Tons	Maximum Compression before Collapse	Remarks
I.		15'0"	37·38	0·19"	Ends thick
II		20'0"	93·02	0·19"	Ends thick
III.		24'0"	152·63	0·30"	Ends thick
IV.		20'0"	177·17	0·34"	Plattens 14"x18" Rivetted at each end
V.		24'0"	194·10	0·25"	Ends flat

FIG. 7.—ROLLED JOISTS TESTED AS STRUTS.

poise weight, the motion of the pen can be regulated at will to give a scale of ordinates of 10 mm., 5 mm., 2 mm., or 1 mm. per ton. The deformation of the test piece is transmitted as abscissæ to the recording drum,

Index	Material	Section	Maximum Load	Amount of Penetration at Max^m Load
I.	Basic Steel	3"x1/2"	29·20 Tons	0·10
II.	" "	3"x1"	46·66 "	0·12
III.	" "	3"x1/2"	84·00 "	0·28
IV.	" "	3"x2"	108·61 "	0·31
V.	" "	3"x2 1/2"	129·54 "	0·55

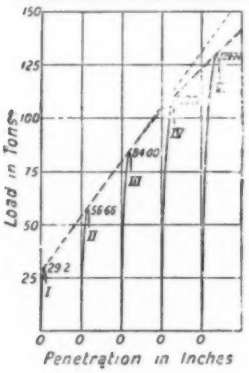


FIG. 8.—SHEARING EXPERIMENTS ON BARS.

being transmitted by suitable wires passing over pulleys which turn the drum in such a manner as to record the deformation either full-sized or multiplied five or ten times." In regard to the accuracy of the machine, he says:—"The superiority of this machine, which may have rivals in mere power, consists more particularly, we believe, in its accuracy, its sensibility, and its convenience of operation. "The determination of its accuracy has been repeatedly proved, by means of calibrated copper crushers, which were crushed in the most delicate machines of the laboratory, which had been carefully checked by dead-weights for the purpose; the results showed themselves uniformly concordant. These experiments were not, it is true, carried out with very heavy loads, but when a machine is inaccurate it is so even at small loads; but in our case no inaccuracy was found. A further test of sensibility was made by applying a load of 100 tons to a long chain with the steel-yard in equilibrium, and half-way between the limits of its range, and then moving the poise weight a fraction of its travel corresponding to 4 lb. upon the steel-yard; this amount, plus or minus, upset the equilibrium. The testing laboratory therefore," he says, "possesses a powerful machine, whose handiness, precision, and sensibility merit every confidence." At the ceremonial opening of the machine on June 16th last a bar of hard steel 4 ins. by 1½ in. in section was broken in tension with a load of 228 tons, and immediately afterwards a large slab of armoured concrete 32 ins. broad, 12 ins. thick, was broken in deflection between supports 16 ft. 6 ins. apart.—*Paper read at the British Association, Section G.*

Flexure of Reinforced Concrete Beams. **Prof. Arthur N. Talbot, University of Illinois.** Having regard to the diversity of views and opinions which exists concerning the action of a combination of steel and concrete and the proper method of calculating the strength of reinforced concrete beams, any contribution to our knowledge of this subject may be useful in fixing principles and settling differences. Hence Prof. Talbot's paper is of prime importance to construction engineers, presenting, as it does, particulars of a series of valuable tests made by him and his deductions therefrom as to the resistance of such beams to flexure. Twenty-two reinforced concrete beams, measuring 15 ft. 4 ins. long by 12 ins. wide and 13½ ins. deep, were tested. The centre of the metal reinforcement was placed 12 ins. below the top of the beam. The span used was 14 ft., the load being applied equally at two points, the third points of the span. This loading does not differ greatly in maximum bending moment and in the shear at the ends from the conditions for uniform loading, and has the advantage for the measurement of deformations that the stresses, except for the dead load, are equal at all points between the two load points. Chicago "AA" Portland cement, bought in the open market, was used; one to three mortar gave 233 lbs. per sq. in. in seven days, and 400 lbs. in sixty days; the sand was fairly clean and well graded in size and contained 29 per cent. voids. The stone used was crushed limestone and ranged between ¼ in. and 1½ in. in size, and contained 44 per cent. voids. The concrete was by loose volume, one cement, three sand, and six stone. The tests were made on an Olsen machine of 200,000 lbs. capacity, and records were taken on a modified form of Johnson's extensometer, with

which readings could be taken to $\frac{1}{10000}$ in. *General Phenomena of the Tests.*—Four stages of flexure are apparently developed during the progress of the loading. Through the first stage, as the load is applied, the action of the beam and the changes in formations of upper and lower fibres, are similar to those in plain concrete beams, modified of course by the metal reinforcement; and the resistance of the tensile stresses of the concrete is plainly apparent. When a load of about 4,000 lbs. for $\frac{4}{10}$ per cent. reinforcement and of about 6,000 lbs. for 1·5 per cent. reinforcement is reached (equivalent to about 250 lbs. per sq. in. when the weight is considered), the second stage begins. The steel elongates more rapidly with the application of the loading, there is a similar increase in the compression of the concrete, the neutral axis rises, and there is a marked change in the character of the load-deformation diagram. While no cracks are visible to the naked eye at this second stage, it is evident that much of the tensional value, of the concrete has been lost. During the third stage the increments of the deformation of the steel are closely proportional to the increments of the load. During this stage vertical cracks appear, generally numerous and distributed along the middle third line of the length of beam, and growing in width. This continues until a point at or near the maximum load is reached, except with those beams having an excess of reinforcement. The stage of failure begins at or near the maximum load. The beam deflects more and more, the load required to balance the scale beam gradually becoming less. The steel stretches rapidly, the neutral axis changes its position, and there is a more rapid compression of the upper fibre of the concrete, until finally it crushes out at the top of the beam at a load below the maximum, after the steel has stretched considerably beyond its yield point. The exception occurs with beams having more than 1 per cent. of metal of 55,000 lbs. per sq. in. elastic limit, or more than 1·5 per cent. of 33,000 lbs. per sq. in. elastic limit. In such beams the concrete at the top fails by crushing before the elastic limit of the steel is reached. In all the others the full compressive strength of the concrete was not developed at the maximum load. *Maximum Load at Yield Point of Metal.*—In a table accompanying the paper it is shown that for the points chosen, which are just below the yield point of the metal and somewhat below the maximum load, the resisting moment for the steel (calculated by multiplying the stress found in the steel by the distance to an assumed centroid of the compressive stresses of the concrete, and thus taking into account an equal amount of compression) is generally approximately equal to the bending moment due to the load, and hence that the moment of the tensile stresses of the concrete is negligible. The exceptions to this are (1) in beams with light reinforcement and low elastic limit, and (2) in beams with an excess of metal. *Stresses in Second and Third Stages.*—The results obtained show that, in general, for loads less than the maximum the resisting moment of the steel based on average deformation for the full-gauge length is considerably less than the bending moment. *Position of Neutral Axis.*—In general the neutral axis may be said to rise during the second stage, and then to remain in one position during the third stage, until the maximum load is reached. It is lower than is given by various theories which have been proposed. The equation $k = 0{\cdot}26 + 18p$ gives the position somewhat accurately, where k is the proportional depth of the neutral surface, and p is the proportional steel area or ratio of area of steel to area of concrete, the depth from the top of the beam to the centre of the steel being used in both cases. *Compressive Stresses.*—It would seem that the ordinary formulæ give a larger compressive stress at the remotest fibre than actually exists there. The relation between stress and deformation near the crushing strength of concrete is probably different from that assumed in such formulæ. *Shear and Adhesion.*—It had been anticipated that some of the beams might fail by diagonal tensile stresses induced by shear. As a means of counteracting this, a portion of the bars in beams with 1 sq. in. metal or more were bent upward outside the one-third points of the beam and inclined diagonally to points about 4 ins. below the top at the ends. In no case was there a crack or failure of the kind usually attributed to shear. *Plain Concrete.*—In plain concrete beams it was observed that the neutral axis is very close to the middle of the depth of the beam. This would indicate that for the beams the co-efficient of elasticity of concrete for tension and that for compression are approximately equal. The Professor appreciates the fact that much is yet to be learnt concerning the internal condition of concrete while subjected to stress, and gives as an illustration the case of the release of the loads on a beam. During and after the release of the loads the fibres must be under stress, and this condition is different to what is ordinarily termed set. It may be important to know whether the crushing strength or the ultimate deformation of the concrete is the more variable, or is more largely influenced by poor mixtures and poor workmanship, and hence to know which is more important as a basis for a factor of safety. Also the effect of encasing steel in concrete upon its elastic properties.—*Journal, Western Society of Engineers, Chicago, August*, 1904.

CATALOGUES AND TRADE PUBLICATIONS.

Feed Pumps.

Thwaites Bros., Ltd., Bradford.—Illustrated brochure descriptive of the Bradford Patent Boiler Feed Pump. This pump, which is of the direct-acting type, has some special features, the most important of which is that the customary shuttle-valve has been eliminated and replaced by a simple-type single valve directly under mechanical control. The arrangement may be briefly explained as follows: A number of small ports are drilled in the top and bottom of the pump-liner, and these ports are so placed that there is direct communication between the two sides of the pump-piston when it is at the top or bottom of its stroke. When the steam-valve is in the neutral position, these ports begin to open, thus destroying the pressure in the pump-cylinder, and enabling the steam in the steam-cylinder to expand and complete the stroke. The completion of the stroke necessarily means that the steam-valve is carried over into such a position that steam is admitted into the opposite end of the cylinder. The amount of opening of these ports can be readily adjusted by the nuts on the valve-spindle, and can be permanently fixed, so that there is no fear of sticking at any speed at which the pump may work.

Boiler-House Plant.

Babcock & Wilcox, Ltd., Farringdon Street, London, E.C.—Pamphlet containing illustrated descriptions of their well-known type of land service boiler, steam superheater, chain grate stoker, water-softener, steam piping and gravity bucket conveyor.

Welding and Casting.

Thermit, Ltd., 27, Martin's Lane, Cannon Street, E.C.—The production of high temperatures by the burning of aluminium, and the application of this to engineering and metallurgy, has now reached a stage of considerable commercial importance. The series of exceedingly instructive sectional pamphlets issued by the exploiters of the system, describe the various operations which are conveniently and economically effected by "Thermit," viz., rail welding, repairs of castings, welding of broken shafts and wheels and production of pure metals free from carbon, etc.

Steam Specialities.

Lancaster & Tonge, Ltd., Pendleton, near Manchester.—Catalogue of steam traps (1903 patents), piston-rings, metallic packings, steam dryer, combined feed-heater and grease-separator.

Machine Tools.

A. Haworth & Sons, Sowerby Bridge.—Illustrated descriptive list of drilling machines for light and accurate work, slotting machines, lathes, shaping machines and mandrel stands.

Air Compressors.

Consolidated Pneumatic Tool Co., Ltd., 9, Bridge Street, Westminster, S.W.—A handsome, well-printed catalogue fully describing and illustrating the constructional details, action, and applications of the air-compressing plant made by them. The booklet is rendered all the more interesting by reason of the excellent chapters dealing with the installation, adjustment, and care of air compressors and the valuable tabular matter contained at the end. The effect of compounding, cooling, inter-cooling, after-cooling and reheating also forms the subject matter of several pages.

Alley & Maclellan, Ltd., Polmadie, Glasgow.—No. 6 Air Pamphlet, in which are described and illustrated a number of "Sentinel" air-compressors recently delivered to leading firms. Another catalogue likely to be of value to all interested in air-compressors is announced, and those desiring a copy should write for "No. 5, Air."

Thermometry.

Cambridge Scientific Instrument Co., Ltd., Cambridge.—List No. 25, on Technical Thermometry. This is really a new and revised edition of the little catalogue issued by the firm some time ago, entitled "The Measurement of Temperature by Electrical Means." The subject of temperature is, of course, a most important one in many of our industries, and is now receiving a great deal of attention at the hands of progressive firms.

Heating.

Holden & Brooke, Ltd., West Gorton, Manchester.—List No. 68, descriptive of Brooke's "Positive Flow" hot-water system of heating buildings, with some information concerning the arrangement of the system as installed for heating the General Post Offices at Manchester and Glasgow.

Draught Gear.

The Westinghouse Brake Co., Ltd., York Road, King's Cross, N.—Illustrated pamphlet descriptive of a new automatic coupler, draw-bar and buffer for railway work with special reference to European requirements.

Oil Firing.

Lucal Light and Heating Co., Ltd., 65, West Regent Street, Glasgow.—Report by Professor Watkinson, Wh.Sch., M.I.Mech.E., on the Lucal Liquid Fuel Burner. The result of the test showed that the evaporation from and at 212 degs. Fahr. amounted to 13·65 lbs. per lb. of oil (blast furnace) burned, the percentage efficiency of the boiler being 75.